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Space Station Integrated Propulsion and Fluid System Study

Fluid Systems Configuration Databook

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ABBREVIATIONS AND ACRONYMS

AFD	Aft Flight Deck
ACS	Attitude Control System
ACS	Atmosphere Control and Supply
AR	Atmosphere Revitalization
B-CRS	Bosch Caron Reactor Subsystem
CFE	Continuous Flow Electrophoresis
ECLSS	Environmental Control and Life Support System
EEU	Extra-vehicular Excursion Unit
ELM	Experimental Logistics Module
ESA	European Space Agency
EVA	Extra-vehicular Activity
F	Fahrenheit
FDS	Fire Detection and Suppression
FMS	Fluid Management System
GPF	Gas Processing Facility
HFM	Hollow Fiber Membrane
HPTA	High Pressure Tank Assembly
HR&T	Heat Rejection and Transport
IFMS	Integrated Fluid Management System
IOC	Integrated Operational Capability
IOC	Integrated Operations Configuration
INS	Integrated Nitrogen System
IWFS	Integrated Waste Fluid System
IWS	Integrated Water System
JEM	Japanese Experiment Module
KOH	Potassium Hydroxide
kW	Kilowatt
lb	Pound
lbm	Pounds Mass
LHe	Liquid Helium
MEOP	Maximum Expected Operating Pressure
MLI	Milti-Layer Insulation
MMU	Manned Maneuvering Unit
MORL	Manned Orbiting Research Laboratory
MSFC	(George C.) Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency (Japanese)
NHB	NASA Handbook
NSTS	National Space Transportation System
OMV	Orbital Maneuvering Vehicle
ORU	Orbit Replaceable Unit
OSCRS	Orbital Spacecraft Consumable Resupply System
OTV	Orbital Transfer Vehicle
PLC	Pressurized Logistics Carrier
PM	Payload Module
PMMS	Process Material Management System
PPV	Portable Pressure Vessels
psia	Pounds Per Square Inch Absolute
PWHS	Process Waste Handling System
RF	Radio Frequency
RMS	Remote Manipulator System

ABBREVIATIONS AND ACRONYMS (continued)

SFHe	Superfluid Helium
SFHT	Superfluid Helium Tanker
SIRTF	Space Infrared Telescope Facility
SMR	Sabatier Methanation Reactor
SS	Space Station
SSP	Space Station Program
SSPE	Space Station Program Element
TBD	To Be Determined
TBS	To Be Determined by Supplier
TCS	Thermal Control System
TED	Thermoelectric Device
THC	Temperature and Humidity Control
ULC	Unpressurized Logistics Carrier
USL	United States Laboratory
U.S.	United States
WHS	Waste Handling System
WM	Waste Management

FOREWORD

This report was prepared by Martin Marietta Space Systems Company, under Contract NAS8-36438 in compliance with data submittal requirement J-1-3 in the Statement-of-Work. The contract is being administered by Marshall Space Flight Center, Huntsville, Alabama. Mr. John Cramer is the NASA Project Manager.

INTRODUCTION

This databook contains fluid system requirements and system descriptions for Space Station Program Elements. Program elements include the United States and International modules, integrated fluid systems, attached payloads, fluid servicers and vehicle accommodation facilities. Fluid system requirements and system configurations were derived from the DR-02, "Databooks from Work Package 1" and October 19896 Fluids Integrated Panel Data. Data contained in this document was used to generate EP 2.2, "Space Station Program Fluid Inventory Databook."

The fluid system requirements and system descriptions of each Space Station Program Elements are defined in the following sections.

Section 1.0	United States Laboratory
Section 2.0	Habitation Module and Airlocks
Section 3.0	Logistics Elements
Section 4.0	Japanese Experimental Module
Section 5.0	Columbus
Section 6.0	Integrated Waste Fluid System
Section 7.0	Integrated Water System
Section 8.0	Integrated Nitrogen System
Section 9.0	Environmental Control and Life Support System
Section 10.0	Thermal Control System
Section 11.0	Attached Payloads
Section 12.0	Fluid Services/Vehicle Accommodations

Each section includes a discussion of the overall system requirements, specific fluid systems requirements and system descriptions. The system descriptions contain configurations, fluid inventory data and component lists. In addition, a list of information sources are referenced at the end of each section.

1.0 UNITED STATES LABORATORY MODULE

1.1 UNITED STATES LABORATORY OVERALL REQUIREMENTS

The USL will be a multidiscipline facility for payload accommodation within a pressurized habitable volume. It will accommodate materials research and development most sensitive to acceleration, research in basic science requiring long duration of extremely low acceleration levels, life sciences research relating to benefits of and adaption to long duration exposure to extremely low acceleration levels and control and monitoring of user-attached pressurized modules and selected external attached payloads.

The microgravity requirement of 10^{-5} for payload operations will enhance materials processes and allow for the advancement of knowledge and the development of process controls. The USL will also accommodate the scale-up to pilot plant operations and the operation of pre-production and commercial facilities in space.

The overall requirements for the United States Lab (USL) Module are presented in Table 1.1-1.

Table 1.1-1 Overall Requirements for the United States Laboratory

1) Accommodate the performance of selected complements of experiments.
2) Provide cooling of 6 kW with selected double-rack cooling of 15 kW to accommodate experiment compliments.
3) Provide a process fluids system.
4) Provide a vacuum vent system.
5) Provide a waste management system.

1.2 UNITED STATES LABORATORY FLUID SYSTEMS REQUIREMENTS

Fluid requirements for the Environmental Control and Life Science System, Thermal Control System, Process Materials Management System, and Vacuum Vent System are provided in Table 1.2-1.

1.3 UNITED STATES LABORATORY FLUID SYSTEMS DESCRIPTIONS AND CONFIGURATIONS

The USL fluid systems may be categorized into four working groups; the Environmental Control and Life Support System (ECLSS), the Thermal Control System (TCS), the Process Materials Management System (PMMS) and the Vacuum Vent System.

1.3.1 Environmental Control and Life Support Systems (ECLSS)

The USL Environmental Control and Life Support System's primary function will be to maintain a habitable environment in which the crew members can perform laboratory experiments. A system description, fluid quantities and component lists of the ECLSS have been included in Section 9 of this report.

The primary ECLSS user interfaces will be in the areas of avionics air cooling and air contamination control. Thermal control interfaces will include cabin heat exchangers, avionics heat exchangers and air revitalization equipment. Manned systems interfaces will include the commode, shower and hand washing systems.

Table 1.2-1 Fluid Systems Requirements for The United States Laboratory

USL Element	USL Fluid System Requirement
Environmental Control and Life Support System*	1) Provide atmospheric pressure and composition control. 2) Provide temperature control and humidity maintenance. 3) Provide atmospheric revitalization. 4) Provide water to meet crew and experimental needs. 5) Provide waste management.
Thermal Control System	1) Provide an integrated system which maintains structures, ancillary compartments, components, subsystems and customer payloads within their specified temperature limits. 2) Provide a method for detecting, locating, isolating and repairing leaks in the TCS system.
Process Material Management System	1) Provide storage and distribution of USL process fluids. 2) Provide safe handling, removal, storage and disposition of USL payload waste by-products. 3) Provide a .25 torr vacuum pressure for waste gas removal from all USL payloads. 4) Not prohibit microgravity research in USL. 5) Comply with Space Station external contamination constraints. 6) No propulsive venting. 7) Interface with Integrated Fluid Management System (IFMS). 8) Provide storage in the gaseous waste handling system of all gases that are not compatible with the IWFS for a minimum of 14 days.
Vacuum Vent System	1) Maintain a high quality vacuum resource for USL user community. 2) Provide a minimum of .001 torr vacuum pressure to experiments.

* Primary control is monitored and maintained by the Space Station core module

1.3.2 Thermal Control System

The thermal control system will consist of three basic cooling loops, a primary experiment loop, an attached payload pump and a refrigerator/freezer loop. The primary experiment loop will be a pumped single-phase water coolant loop which services the experiment racks, the avionics cooling heat exchanger and the cabin condensing heat exchanger. Waste heat from this primary loop will be transferred to the Space Station Heat Rejection and Transport System (HR&T) through central bus heat exchangers mounted on the exterior of the USL end cone structure.

The attached payload loop will be used to cool equipment in adjacent nodes. This loop will also use single-phase water as the working fluid.

Refrigeration/freezing services will be provided to the USL with an integrated air/freon cooling loop. Heat acquired in the freezer will be transferred to low temperature body mounted radiators to reject the heat necessary to meet a -30°C freezer requirement.

The TCS will be a closed loop system that does not require scheduled fluid resupply and as a result will be considered independent from the integrated fluid systems. Accommodations have been made in the TCS for fluid leakage and system purging to remedy system contamination. However, the fluid quantities specified may be considered insignificant in comparison to the overall water inventory of the Space Station elements.

1.3.3 Process Material Management System (PMMS)

The Process Material Management System will be responsible for two major USL services. The first Service is the storage and distribution of USL process fluids and the second is the safe handling, removal, storage and disposal of USL payload waste by-products. Figure 1.3-1 shows an overview of the entire PMMS responsibilities.

1.3.3.1 Process Fluids Storage and Distribution

Process Fluids Supply

The PMMS will be responsible for the storage and distribution of specific consumable gases and liquids used by the USL facilities and laboratory support equipment. Process fluids include water, helium gas, nitrogen gas, argon gas, oxygen gas, carbon dioxide gas and hydrogen gas. Fluid groups such as etchants, solvents, buffers, cleaning fluids, xenon, acetylene gas and fuels were identified as possible process fluid candidates but are required in small quantities or by single users and have been defined as being user supplied.

Several experiment payloads have requested to use liquid nitrogen and liquid helium. These fluids are requested for their thermal properties and not necessarily required to perform the experiment. The Critical Point Facility is the only exception which will utilize LN2 and LHe as part of the experiment other than for cooling. To minimize long term storage problems associated with cryogenics and system complexity, experiment cooling will be provided by a closed loop helium refrigeration cycle. This concept, discussed in greater detail under the cryogenics section will provide a 138.6 K temperature level when required, and in the process will eliminate cryogenic storage and transportation problems.

The closed loop cryogenic refrigeration cycle will not require helium resupply with the exception of leakage makeup. As a result, the only requirement for liquid helium is requested by the Critical Point Facility. Because of the large amount of power required for liquid helium production, liquid helium has been recommended to be user provided.

Liquid nitrogen will be produced by transferring gaseous nitrogen from the ECLSS system and cooling it with the helium refrigeration system in a portable dewar. The liquid nitrogen will then be transported in the dewar to the experiment.

The PMMS will be required to provide a 90 day supply of the process fluid quantities previously mentioned. These fluid quantities and storage interface requirements for the storage and distribution system are summarized in Tables 1.3-1 and 1.3-2. A list of components for the storage and distribution system is also provided in Table 1.3-3.

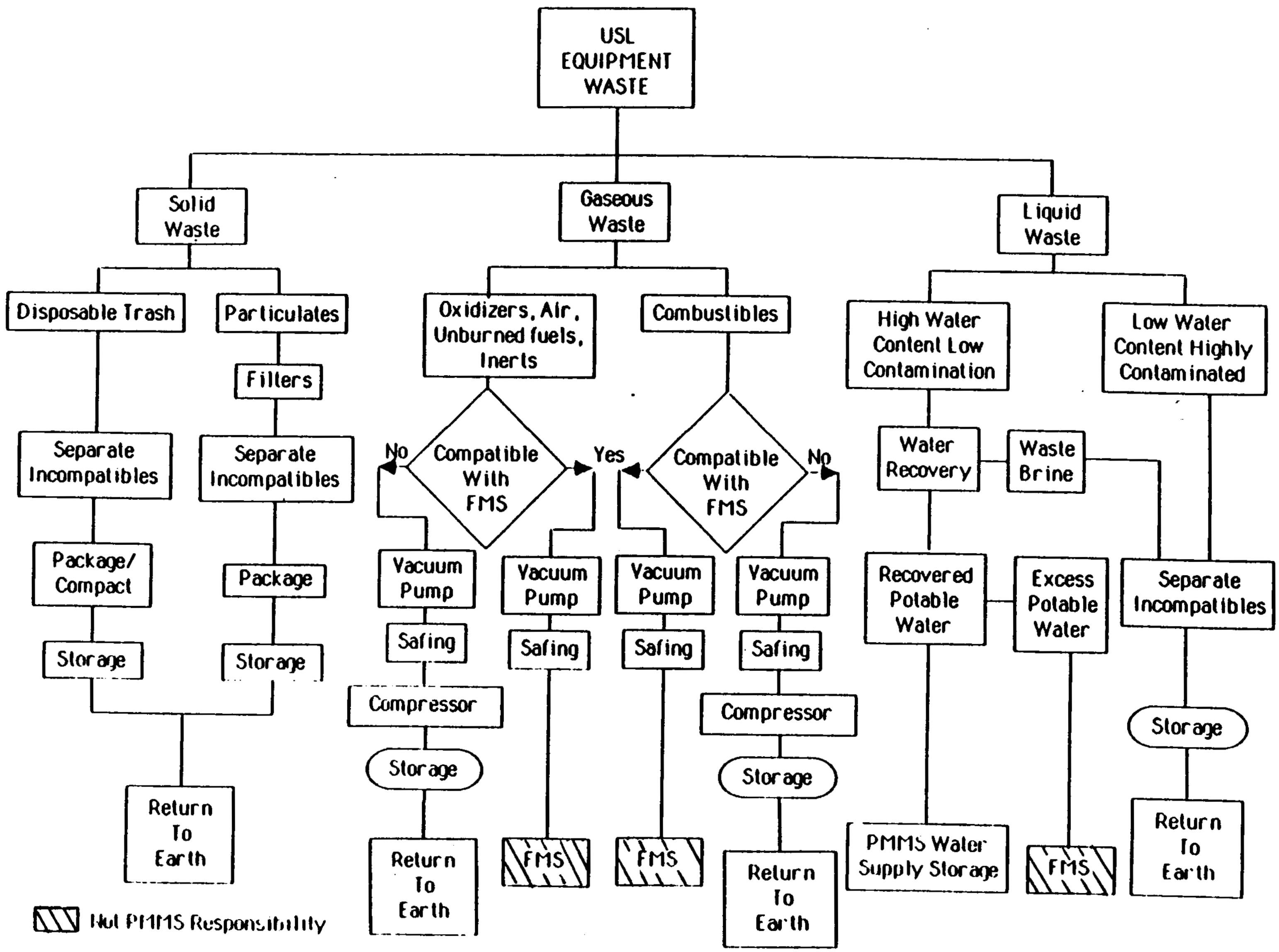

Figure 1.3-1 Process Material Management System Overview

Table 1.3-1 USL Process Material Management System Fluid Inventory Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS) MEAN	RESUPPLY QUANTITY (LB/90 DAYS) MAX	RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
32	USL	CRYOGENIC	GHe	TBD	4.2 CFM MAX/.26 MIN	0	LEAKAGE MAKEUP	SUPPLY LINE	TBD	CLOSED LOOP REFRIGERATION SYSTEM.
2	USL	PFS	H2O	992.3	TBD	1130	5072	FLUID TRANSFER	99.5 % PURE	ASSUMES 85% WASTE WATER RECOVERY WITH PMMS.
3	USL	PFS	GN2	255.3		161.0	170.2	ECLSS	TBD	
4	USL	PFS	GO2	42.6	TBD	22.9	28.4	ECLSS	TBD	
5	USL	PFS	GHe	3.5	TBD	1.9	2.2	FLUID TRANSFER/PPV	TBD	
6	USL	PFS	GH2	77.7 SCF	TBD	0.7	0.8	FLUID TRANSFER	TBD	
7	USL	PFS	Ar	55.5	TBD	32.6	37.0	FLUID TRANSFER/PPV	TBD	
8	USL	PFS	CO2	54.6	TBD	26.0	36.4	PPV	TBD	
10	USL	PFS	FREON	1.4	TBD	0.8	0.9	FLUID TRANSFER	TBD	
11	USL	PFS	AIR	0.0	TBD	89.3	97.7	FLUID TRANSFER FROM ECLSS	SEE REMARKS	PPO2=2.83 TO 3.35 PSIA PPN2=11.87 TO 11.35 PSIA
12	USL	PFS	Xe	28.1	TBD	10.9	18.7	PPV	TBD	
13	USL	PFS	ACETYLENE	TBD	TBD	0.0	0.0	PPV	TBD	
14	USL	PFS	CLEANING SOL'N	248.4	TBD	117.1	165.6	PPV	TBD	
16	USL	PFS	CUTTING POLISH	TBD	TBD	TBD	TBD	PPV	TBD	
17	USL	PFS	ETCHANTS	TBD	TBD	TBD	TBD	PPV	TBD	
18	USL	PFS	SOLVENTS	TBD	TBD	TBD	TBD	PPV	TBD	
19	USL	PFS	BUFFER SOLUTION	TBD	TBD	TBD	TBD	PPV	TBD	
20	USL	PFS	FUELS	TBD	TBD	TBD	TBD	PPV	TBD	
21	USL	PFS	BUTANE	TBD	TBD	TBD	TBD	PPV	TBD	
22	USL	PFS	METHANE	TBD	TBD	TBD	TBD	PPV	TBD	
23	USL	PFS	PROPANE	TBD	TBD	TBD	TBD	PPV	TBD	
24	USL	PFS	ALCOHOL	TBD	TBD	TBD	TBD	PPV	TBD	
25	USL	PFS	TOLUENE	TBD	TBD	TBD	TBD	PPV	TBD	
26	USL	PFS	XYLENE	TBD	TBD	TBD	TBD	PPV	TBD	

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Table 1.3-1 (Continued) USL Process Material Management System Fluid Inventory Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS)		RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
						MEAN	MAX			
27	USL	PFS	STERILIZERS	TBD	TBD	TBD	TBD	PPV	TBD	
28	USL	PFS	STAINS	TBD	TBD	TBD	TBD	PPV	TBD	
29	USL	PFS	CULTURE MEDIA	TBD	TBD	TBD	TBD	PPV	TBD	
30	USL	PFS	NUTRIENTS	TBD	TBD	TBD	TBD	PPV	TBD	
34	USL	PWH	MIXTURE	NA	3.178 cfm max	NA	NA	NA	SEE TABLE 1.3-6	
31	USL	WATER RECOVERY SYS.	H2O	992.3	.176 CFM	1130	TBD	TRANSFER FROM ORBITER	POTABLE WATER	WATER IS TRANSFERED FROM ORBITER FUEL CELLS AND ECLSS TO NODE STORAGE SYSTEM.

PWH - Process Waste Handling
Mixture - Fluids and Gases Listed in Table 1.3-5

Table 1.3-2 USL Process Material Management System Fluid Interface Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	INLET AND OUTLET FLUID CONDITIONS				METHOD OF WASTE MANAGEMENT	FAILURE TOLERANCE	REMARKS
				FROM TO	PRESSURE (PSIA)	TEMP. (F)	LINE SIZES (INCHES)			
32	USL	CRYOGENIC	GHe	STORAGE EXPERIMENT	300 <300	113 -321	.75 .75	RECYCLED	NONE	DELIVERY IS NOT FAILURE TOLERANT
2	USL	PFS	H2O	NODE FILTRATION	TBD 100	TBD 70	.375 .375	PMMS	ZERO	FAILSAFE
3	USL	PFS	GN2	ECLSS EXPERIMENT	200 50	70 70	.375 .250	PMMS	ZERO	FAILSAFE
4	USL	PFS	GO2	ECLSS EXPERIMENT	250 50	70 70	.375 .25	PMMS	ZERO	FAILSAFE
5	USL	PFS	GHe	LOG MODULE EXPERIMENT	3000/2000 50	70 70	.25 .25	PMMS	ZERO	FAILSAFE
6	USL	PFS	GH2	HYDRIDE TANK EXPERIMENT	100 50	90 90	.375 .250	PMMS	ZERO	FAILSAFE
7	USL	PFS	Ar	LOG MOD EXPERIMENTS	3000/2000 50	70 70	.25/PPV .25	PMMS	ZERO	FAILSAFE
8	USL	PFS	CO2	LOG MOD EXPERIMENT	2000 TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
10	USL	PFS	FREON	LOG MOD EXPERIMENT	2000 TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
11	USL	PFS	AIR	ECLSS EXPERIMENT	14.7 70	70 14.7	.25 .25	PMMS	ZERO	FAILSAFE
12	USL	PFS	Xe	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
13	USL	PFS	ACETYLENE	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE

Table 1.3-2 (Continued) USL Process Material Management System Fluids Interface Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	INLET AND OUTLET FLUID CONDITIONS				METHOD OF WASTE MANAGEMENT	FAILURE TOLERANCE	REMARKS
				FROM TO	PRESSURE (PSIA)	TEMP. (F)	LINE SIZES (INCHES)			
14	USL	PFS	CLEANING SOL'N	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
16	USL	PFS	CUTTING POLISH	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
17	USL	PFS	ETCHANTS	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
18	USL	PFS	SOLVENTS	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
19	USL	PFS	BUFFER SOLUTION	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
20	USL	PFS	FUELS	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
21	USL	PFS	BUTANE	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
22	USL	PFS	METHANE	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
23	USL	PFS	PROPANE	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
24	USL	PFS	ALCOHOL	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
25	USL	PFS	TOLUENE	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
26	USL	PFS	XYLENE	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
27	USL	PFS	STERILIZERS	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
28	USL	PFS	STAINS	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
29	USL	PFS	CULTURE MEDIA	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
30	USL	PFS	NUTRIENTS	LOG MOD EXPERIMENT	TBD TBD	70 70	PPV PPV	PMMS	ZERO	FAILSAFE
34	USL	PWH	MIXTURE	EXPERIMENT IWFS	.005-500 500	TBD 70	2 2	SAFING COMPONENTS BEFORE IWFS		FAILURE TOLERANT
31	USL	WATER RECOVERY SY	H2O	USL STORAGE WATER PURIFICATION	100 50	70 75	.375 .375	CONTINUOUS RECYCLING	NONE	MUST BE DEIONIZED AND PYROGEN FREE, POTABLE AND DISTILLED. SUPPLY NOT FAILURE TOLERANT.

Mixture - Various combinations of constituents in Table 1.3-5.

Table 1.3-3 USL Process Material Management System Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
11	USL, PFS	DISCONNECT,	12	.25	3000	GHE, AR	0.7	TBD	TBD
30	USL, PFS	DISCONNECT,	44	.25	100	H2O	0.7	TBD	TBD
33	USL, PFS	DISCONNECT,	36	.375	100	H2O	0.7	TBD	TBD
14	USL, PFS	FILTER, INLINE	1	.375	100	H2O	5.5	TBD	TBD
7	USL, PFS	MISC, FLEX HOSE	1	.375	50	H2O	1.1	TBD	TBD
12	USL, PFS	MISC, FLEX HOSE	1	.375	100	H2O	0.4	TBD	TBD
32	USL, PFS	MISC, FLEX HOSE	44	.375	100	H2O	2.5	TBD	TBD
35	USL, PFS	MISC, FLEX HOSE	20	.25	50	GHE, AR	0.15	TBD	TBD
23	USL, PFS	MISC, PUMP	1	.375	100	H2O	11.4	TBD	TBD
16	USL, PFS	MISC, WATER PROCESSOR	1	.375	100	H2O	66.2	TBD	TBD
19	USL, PFS	PRESSURE VESSEL,	1	.375	100	H2O	33.1	TBD	TBD
27	USL, PFS	PRESSURE VESSEL,	6	.25	3000	GHE	26.0	TBD	TBD
28	USL, PFS	PRESSURE VESSEL,	6	.25	3000	AR	36.4	TBD	TBD
29	USL, PFS	PRESSURE VESSEL, PORTABLE	18	.25	2000	ALL BUT H2O	12.5	TBD	TBD
15	USL, PFS	PRESSURE VESSEL, PROCESS WATER	1	.375	100	H2O	1080.3	TBD	TBD
21	USL, PFS	PRESSURE VESSEL, STORAGE CONT.	1	.375	50	H2O	15.4	TBD	TBD
24	USL, PFS	REGULATOR, DOWNSTREAM	2	.25	3000	GHE, AR	2.9	TBD	TBD
13	USL, PFS	SENSOR, FLOW METER	2	.375	100	H2O	2.0	TBD	TBD
18	USL, PFS	SENSOR, PRESSURE	2	.375	3000	GHE, AR	0.7	TBD	TBD
22	USL, PFS	SENSOR, PRESSURE DROP	1	.375	100	H2O	0.3	TBD	TBD
25	USL, PFS	SENSOR, QUALITY METER	1	.375	100	H2O	2.2	TBD	TBD
6	USL, PFS	SENSOR, TEMPERATURE	2	.25	3000	GHE, AR	1.1	TBD	TBD
10	USL, PFS	VALVE, CHECK	1	.25	3000	GHE, AR	0.7	TBD	TBD
17	USL, PFS	VALVE, CHECK	2	.375	100	H2O	0.9	TBD	TBD
8	USL, PFS	VALVE, FLOW RESTRICTOR	2	.375	3000	GHE, AR	0.2	TBD	TBD
20	USL, PFS	VALVE, FLOW RESTRICTOR	1	.375	100	H2O	0.3	TBD	TBD
9	USL, PFS	VALVE, SOLENOID	12	.25	3000	GHE, AR	2.5	TBD	TBD
26	USL, PFS	VALVE, SOLENOID	2	.375	100	H2O	2.8	TBD	TBD
31	USL, PFS	VALVE, SOLENOID	1	.375	100	H2O	8.6	TBD	TBD
34	USL, PFS	VALVE, SOLENOID	36	.25	50	GHE, AR	2.5	TBD	TBD
37	USL, PWH	DISCONNECT,	11	1.0	14.7	ALL	0.9	TBD	TBD
48	USL, PWH	DISCONNECT,	4	.25	14.7	ALL	0.5	TBD	TBD
58	USL, PWH	DISCONNECT,	1	.25	14.7	ALL	1.5	TBD	TBD
64	USL, PWH	DISCONNECT,	10	2.0	14.7	ALL	1.8	TBD	TBD
76	USL, PWH	DISCONNECT,	72	1.0	14.7	ALL	0.9	TBD	TBD
82	USL, PWH	DISCONNECT,	3	.25	14.7	ALL	0.5	TBD	TBD
85	USL, PWH	DISCONNECT,	18	1.0	14.7	ALL	0.9	TBD	TBD
54	USL, PWH	ENGINE, BURNER, CATALYTIC	2	2.0	TBD	TBD	60.01	TBD	TBD

Table 1.3-3 (Continued) USL Process Material Management System Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
39	USL, PWH	FILTER, INLINE	13	TBD	TBD	ALL	1.0	TBD	TBD
73	USL, PWH	FILTER, MULTIPLE	1	.375	100	H2O	48.5	TBD	TBD
67	USL, PWH	MISC, COMPRESSOR, REFRIGERATION	1	.75	300	GHE	141.1	TBD	TBD
59	USL, PWH	MISC, CRYO UNIT, LN2 PRODUCTION	1	.25	300	LN2	33.0	TBD	TBD
40	USL, PWH	MISC, DIFFUSER, SUCTION	14	1.0	300	ALL	0.4	TBD	TBD
72	USL, PWH	MISC, FLEX HOSE	4	.75	300	LHE	0.6	TBD	TBD
46	USL, PWH	MISC, FLEX HOSE, TEFLON LINED	4	1.0	14.7	ALL	0.5	TBD	TBD
50	USL, PWH	MISC, FLEX HOSE, TEFLON LINED	1	1.0	14.7	ALL	0.8	TBD	TBD
69	USL, PWH	MISC, FLEX HOSE, TEFLON LINED	6	2.0	100	ALL	1.9	TBD	TBD
78	USL, PWH	MISC, FLEX HOSE, TEFLON LINED	12	1.0	14.7	ALL	0.5	TBD	TBD
83	USL, PWH	MISC, FLEX HOSE, TEFLON LINED	3	1.0	14.7	ALL	0.8	TBD	TBD
84	USL, PWH	MISC, FLEX HOSE, TEFLON LINED	15	1.0	14.7	ALL	0.3	TBD	TBD
86	USL, PWH	MISC, FLEX HOSE, TEFLON LINED	3	1.0	14.7	ALL	0.8	TBD	TBD
77	USL, PWH	MISC, PRETREATMENT UNIT, WASTE	2	2.0	100	ALL	10.0	TBD	TBD
70	USL, PWH	MISC, PUMP	2	2.0	14.7/100	ALL	22.9	TBD	TBD
57	USL, PWH	MISC, PUMP, VACUUM	3	2.0	.25 TORR/14.7	ALL	550.1	TBD	TBD
45	USL, PWH	MISC, SEPARATOR, GAS/LIQUID	7	TBD	TBD	ALL	12.0	TBD	TBD
61	USL, PWH	MISC, TIMES UNIT	1	.375	100	H2O	95.0	HAMILTON STANDARD	TBD
81	USL, PWH	MISC, VACUUM UNIT, PORTABLE	1	TBD	TBD	ALL	10.0	TBD	TBD
51	USL, PWH	PRESSURE VESSEL,	7	2.0	TBD	ALL	14.0	TBD	TBD
65	USL, PWH	PRESSURE VESSEL,	1	.375	TBD	BRINE	7.5	TBD	TBD
44	USL, PWH	PRESSURE VESSEL, LIQUID WASTE	7	.25	TBD	ALL	5.0	TBD	TBD
75	USL, PWH	PRESSURE VESSEL, MATERIAL TRANS. CONT.	1	TBD	TBD	ALL	9.9	TBD	TBD
42	USL, PWH	PRESSURE VESSEL, WASTE CONTAINMENT	7	.25	TBD	ALL	18.0	TBD	TBD
55	USL, PWH	PRESSURE VESSEL, WASTE GAS	2	2.0	TBD	ALL	703.4	TBD	TBD
68	USL, PWH	PRESSURE VESSEL, WASTE HOLDING	1	2.0	TBD	ALL	15.0	TBD	TBD
43	USL, PWH	REGULATOR,	14	1.0	TBD	ALL	2.0	TBD	TBD
41	USL, PWH	SENSOR, FLOW METER	2	TBD	14.7	ALL	0.8	TBD	TBD
80	USL, PWH	SENSOR, FLOW METER	12	TBD	14.7	ALL	0.8	TBD	TBD
47	USL, PWH	SENSOR, PRESSURE	65	TBD	14.7	ALL	0.4	TBD	TBD
66	USL, PWH	SENSOR, PRESSURE	7	TBD	TBD	ALL	0.7	TBD	TBD
60	USL, PWH	SENSOR, QUALITY MONITOR	2	TBD	TBD	H2O	22.1	TBD	TBD
49	USL, PWH	SENSOR, TEMPERATURE	14	TBD	TBD	ALL	0.1	TBD	TBD
62	USL, PWH	SENSOR, TEMPERATURE	1	TBD	TBD	H2O	1.1	TBD	TBD
36	USL, PWH	VALVE, CHECK	8	.25	TBD	ALL	0.6	TBD	TBD
71	USL, PWH	VALVE, CHECK	3	.375	TBD	ALL	0.9	TBD	TBD
52	USL, PWH	VALVE, RELIEF	1	.25	TBD	ALL	1.5	TBD	TBD
53	USL, PWH	VALVE, RELIEF	2	TBD	TBD	ALL	3.9	TBD	TBD
79	USL, PWH	VALVE, RELIEF	4	.25	TBD	ALL	1.5	TBD	TBD

All includes HE, AR, H20, R, CO2

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Table 1.3-3 (Continued) USL Process Material Management System Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
38	USL, PWH	VALVE, SOLENOID	50	1.0	TBD	ALL	2.5	TBD	TBD
63	USL, PWH	VALVE, SOLENOID	2	TBD	TBD	ALL	1.7	TBD	TBD
74	USL, PWH	VALVE, VENT ASSY	2	2.0	TBD	ALL	3.9	TBD	TBD

All includes HE, AR, H2O, FR, CO2

Process Fluids Storage

Process fluids can be separated into three separate storage categories; 1) USL dedicated PMMS storage, 2) Space Station integrated fluids storage and user unique storage. Fluids which require USL dedicated storage include helium, argon, carbon dioxide gases and some water. Potable water will be obtained through excess potable water generation from the ECLSS and Orbiter fuel cells. A separate dedicated storage facility will be located in the laboratory to provide for the necessary water accumulation.

Integrated fluids include excess oxygen and possibly excess hydrogen generated from the ECLSS which may be available for payload use. These fluids, along with nitrogen, transferred from the integrated nitrogen system, will not require dedicated storage in the USL. User unique fluids refer to the remainder of the fluids required by USL payload equipment which also do not require dedicated storage and must be provided by the users.

Helium, Argon, carbon dioxide, and water will be stored in a combination of racks located in the USL floor. Figure 1.3-2 shows the general design concept for the storage and fluid distribution of these fluids. The three gases will be stored under pressure in two types of vessels. Carbon dioxide, and small quantities of helium and argon will be stored in small portable pressure vessels (PPV) at 2000 psia. These vessels will be approximately 14 inch by 6 inch cylinders designed to fit both the fluid storage rack and the fluid user rack. The other gas storage vessel will be a high operating pressure vessel which feeds helium and argon into a general hardline distribution system to the experiments. These vessels will be approximately 30 inch by 9 inch cylinders which operate up to 3000 psia. Nitrogen will be supplied by the Integrated Nitrogen System (INS) located on the station truss structure.

Providing hydrogen presents several safety related design concerns. Hydrogen gas is explosive in nature, therefore large concentrations of hydrogen gas quantities should be avoided. Hydrogen supplied from the ECLSS will be transferred to the USL module and stored in tanks that are approximately 33.7 ft^3 in volume.

Oxygen will also be supplied from the ECLSS system. Presently, this is the only source necessary to meet the 90 day resupply requirement.

Water may be supplied to the dedicated storage facility from the integrated water system which receives excess water from several sources. These sources include excess potable water generated from the ECLSS and the Orbiter fuel cells. The dedicated water storage tank will be capable of holding 992.3 lbm of water at a storage pressure of 100 psia.

Process Fluid Distribution

The PMMS will supply fluids to user equipment by two methods. Water, nitrogen, oxygen, argon and helium will be transferred directly from the storage facility to the user. Carbon dioxide and portions of argon and helium will be supplied from portable pressure vessels (PPV), which can be plugged directly into the user rack.

Processed Water Design Concept

Water quality requirements vary among different users. Twenty-six users require various water purities ranging from potable to deionized and pyrogen-free water as shown in Table 1.3-4. The potable water in the storage tank must be purified to meet the needs of the deionized/pyrogen free water users.

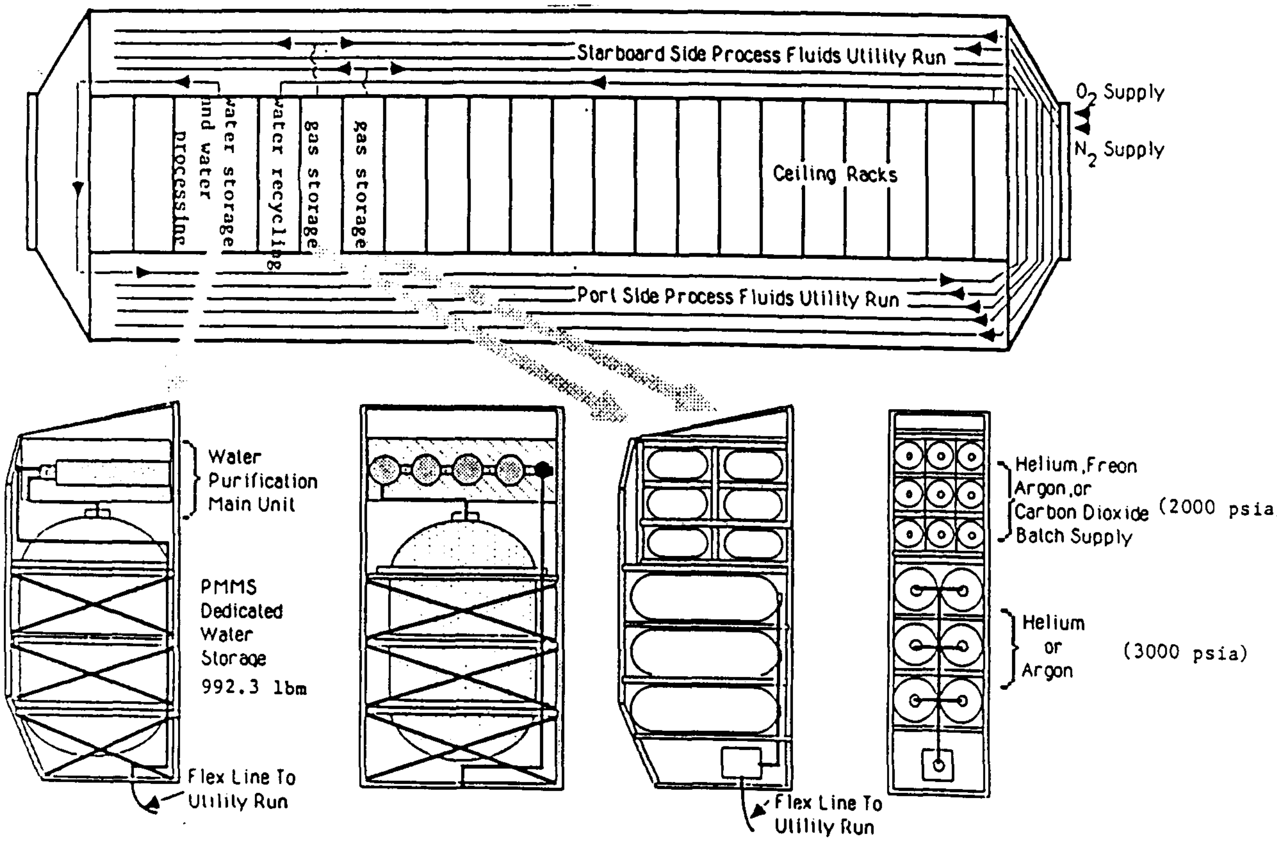

Figure 1.3-2 General Design Concept for USL Storage and Distribution

Table 1.3-4 Process Water Purity Requirements

Equipment Name	Potable	Distilled	Deionized	Pyrogen-free
Automated Cutting and Polishing	X			
Analytical Scale			X	X
Acoustic Levitator		X		
Atmospheric Microphysics Facility			X	
Optical Fiber Pulling	TBD	TBD	TBD	TBD
High Temperature Furnace		X	X	
Auto Ignition			X	
Droplet Spray Burning			X	
Continuous Flow Electrophoresis			X	X
Free Float		X		
High Performance Liquid Chromatograph	TBD	TBD	TBD	TBD
Isoelectric Focusing			X	X
Organic and Polymer			X	X
Membrane Production			X	
Microwave Steam Autoclave	TBD	TBD	TBD	TBD
Protein Crystal Growth			X	X
Solution Crystal Growth			X	
Small Bridgeman	X			
Electrostatic Levitator		X		
EM Levitator		X		
Float Zone	TBD	TBD	TBD	TBD
Fluid Physics			X	
Premixed Gas Combustion			X	
Rotating Spherical Convection		X		
Solid Surface Burning			X	

Figure 1.3-3 shows the water supply design concept for the PMMS. Potable water will be mixed in a common line which feeds the main deionized/ depyrogenation unit. The main unit which will be a combination of multifiltration units linked in series with an ultrafiltration device. The output water, which will meet all purity specifications, will then transferred to the users through utility runs in 3/8 inch tubing.

Cryogenics

The cryogenic facility shown in Figure 1.3-4 will be a closed loop helium system designed to provide cooling to the experiments. The hardware that will comprise the refrigeration system includes a compressor package, a cold head and a distribution line. The compressor package will include a water cooled reciprocating compressor, a heat exchanger, and the associated electrical controls. The cold head will be composed of one or two stage Sterling Cycle expansion device for LN2 generation and the distribution line will provide a means for the supply and return of helium. This closed loop cryogenic refrigeration cycle will not require helium resupply with the exception of makeup for helium leakage.

A small quantity of liquid nitrogen has been requested to support the Critical Point Facility. Gaseous nitrogen will be supplied from the ECLSS system and transferred into the cold head dewar. Cooled by the helium refrigeration system, the nitrogen will then be transferred to users.

1.3.3.2 Process Waste Handling System - The Process Waste Handling System (PWHS) will be responsible for the safe removal, storage and disposal of USL payload waste by-products. An overview of the (PWHS) is provided in Figure 1.3-5. The source of waste will be from payload experiments, support equipment, and processes including a laminar flow work bench, fluids and particular glovebox, emergency shower, and eyewash. A component list of the PWHS is provided in Table 1.3-3.

Figure 1.3-6 shows a layout of a typical rack in which three phase waste will be produced and the associated hardware required to provide the necessary waste management functions. The associated hardware will make up the waste handling assembly which will be required in all payloads requiring gas/liquid separation.

The waste handling assembly will be a vacuum contained housing for the waste handling hardware. The system provides a dynamic recirculation loop for removing liquids from waste gases. When the liquid has been removed, the waste gas is diverted to the Waste Gas Handling System and the experiment is purged.

Gas/Liquid Separation

Spacelab water separators, modified for corrosive conditions will be used to provide gas/liquid separation. The separators are capable of providing three times the liquid pumping capability required in the USL and are physically larger than is desired for the USL. The predicted efficiency of the separator is approximately 99% which means that approximately 1% of all the liquid waste listed in Table 1.3-5 will be transferred into the waste gas handling system and possibly in the integrated waste management system. Liquid/gas separators will be provided in three facilities, the life science glove box, the crystal growth experiment and the materials glove box.

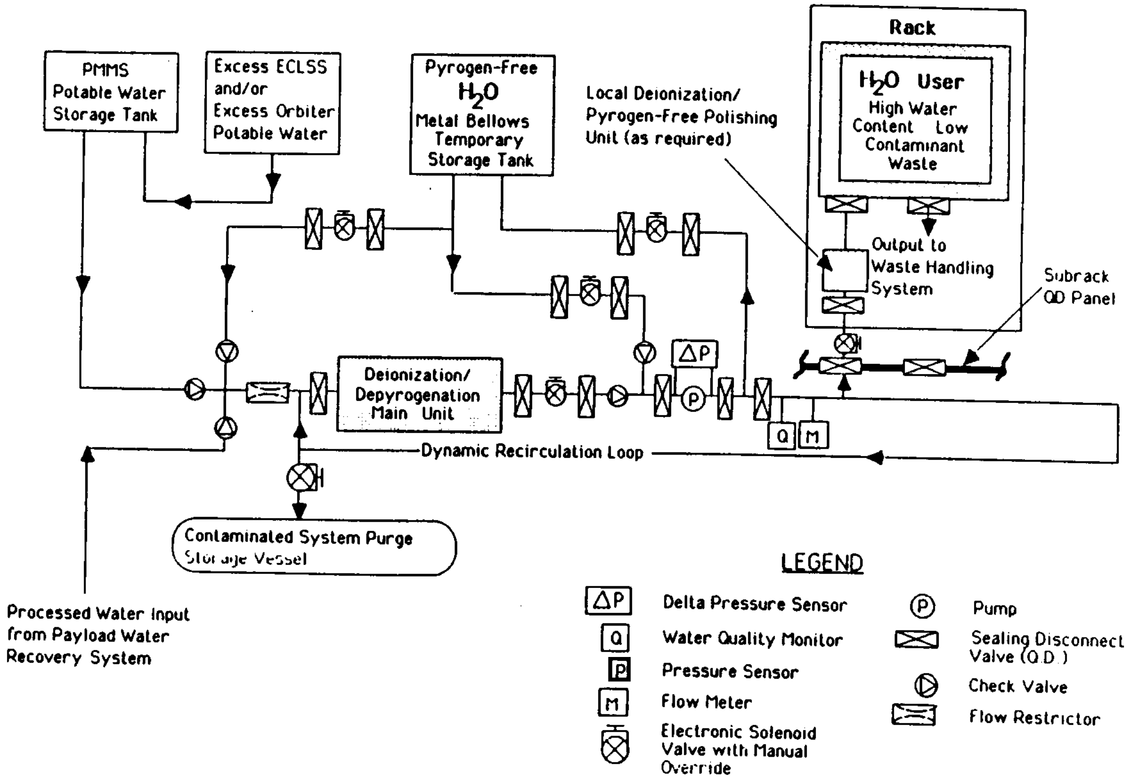

Figure 1.3-3 PMMS Water Supply Design Concept

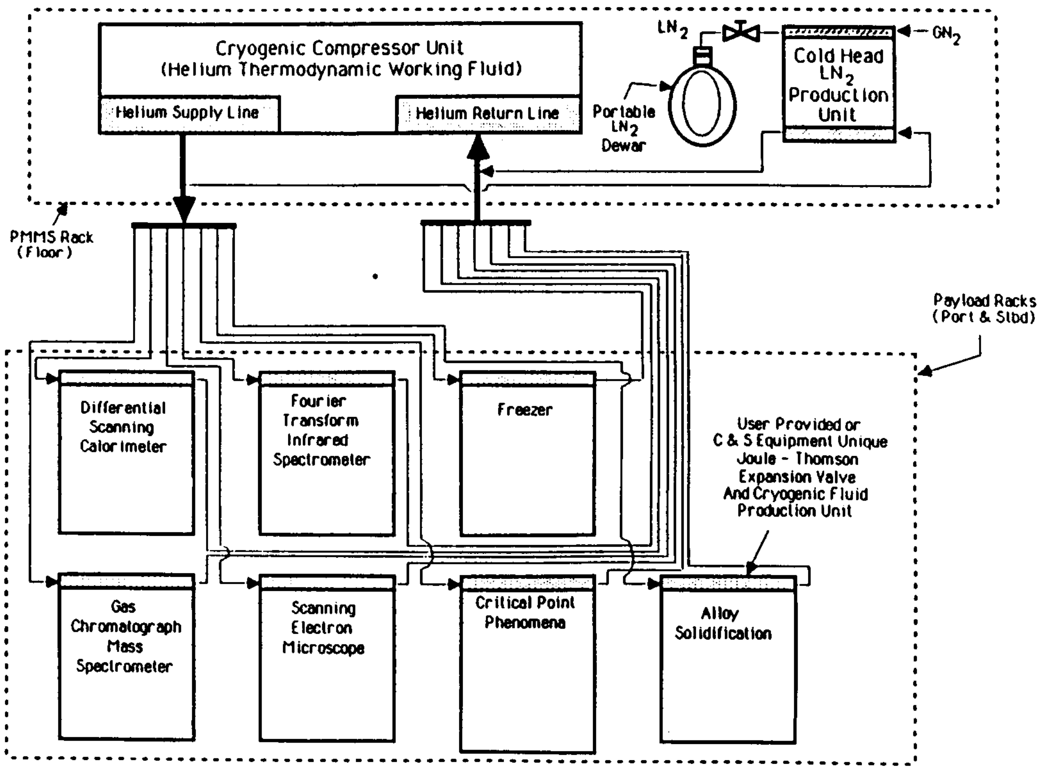

Figure 1.3-4 USL Cryogenic Refrigeration System

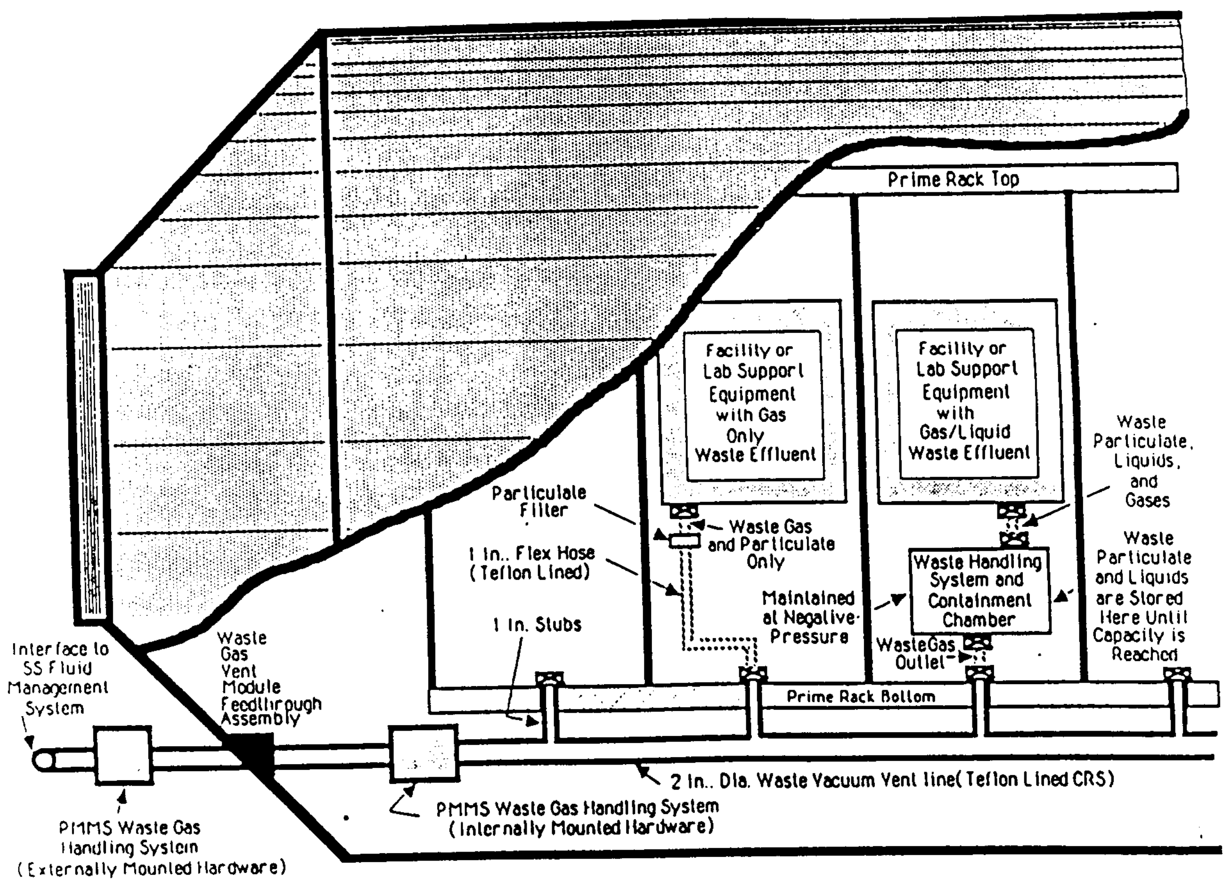

Figure 1.3-5 Overview of the Process Waste Handling System

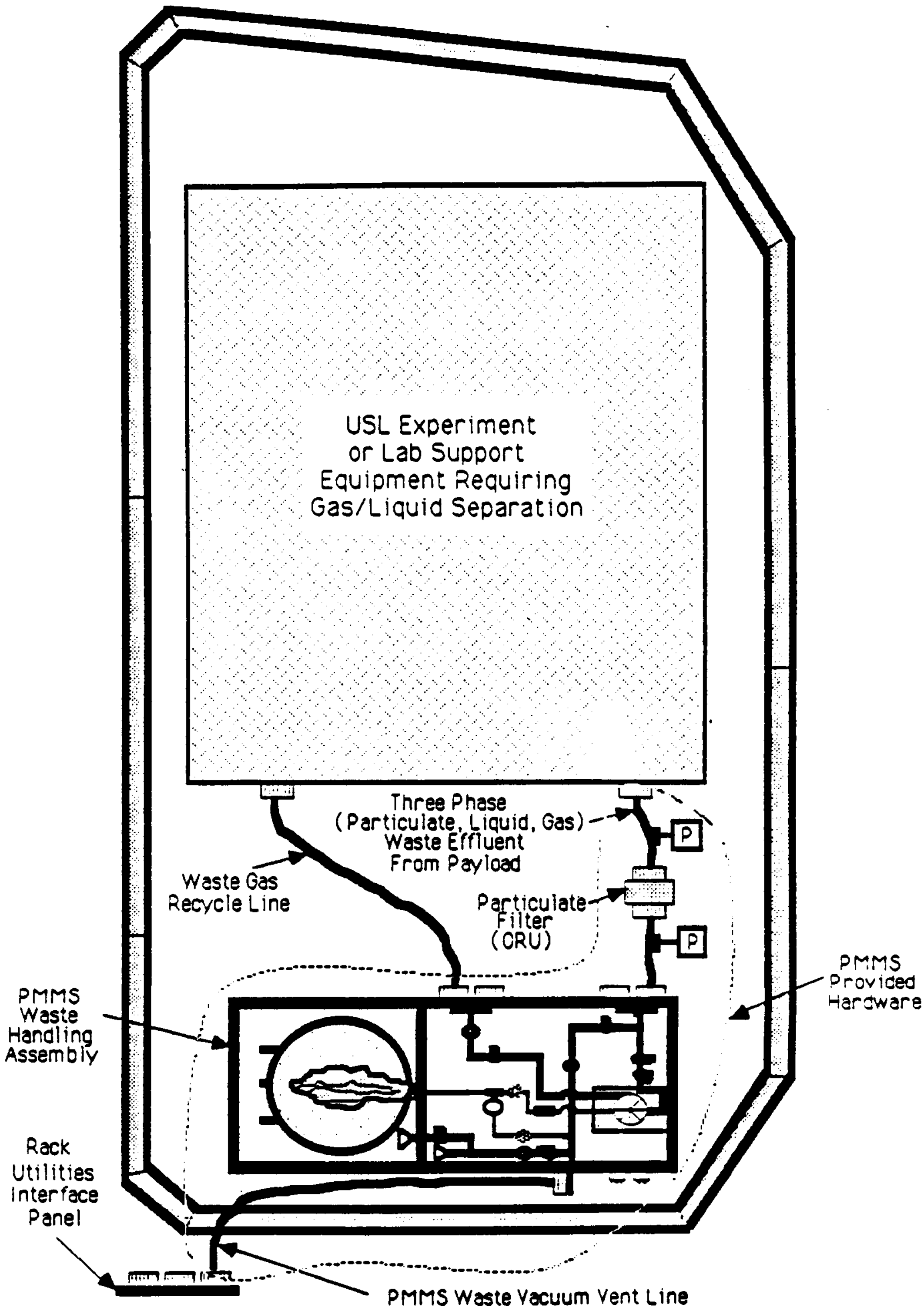

Figure 1.3-6 Process Waste Handling System Design Concept

Table 1.3-5 Liquid and Gaseous Wastes from USL Experiments

LIQUIDS

ORGANICS

Toluene
Freon 22(Chlorodifluoromethane)
Freon 113(Trichlorotrifluoroethane)
Allyl Alcohol
N-Butyl Alcohol
Cyclohexanol
Isopropyl Alcohol
Phenol
Acrolein
Trimethyl Benzene
Indene
Xylene
Diisebutyl Ketone
Methylethyl Ketone
Furan
Butyl Lactate
Dichloromethane
Trichloroethane
Polyphenylene Sulfides
TGS Solution (Triglycene Sulfate)
Spent TGS Solution
Gluderaldehyde

INORGANICS

Ammonia
Latex Solution
Water

SOLVENTS

Benzene
Trichloroethylene
Acetone

ETCHANTS (USED PRIMARILY IN THE GLOVEBOX)

Hydro-fluoric Acid [HF]
Nitric Acid (HNO_3)
Acetic Acid [$(CH_3CO)_2O$]
Silver Nitrate [$AgNO_3$]
Magnesium Iodide [MgI_2]
Hydrogen Peroxide [H_2O_2]
Water [H_2O]
Sodium Hydroxide [NaOH]
Cupric Nitrate [$Cu(NO_3)_2$]
Bromine [Br_2]
Sodium Hypochlorite [NaOCl]
Potassium Hydroxide [KOH]
Potassium Ferricyanide [$K_3Fe(CN]_6$
Hydrochloric Acid [HCl]
Methanol [CH_3OH]
Perchloric Acid

OTHER LIQUID WASTE SOLUTIONS

Buffer Solution
Culture Medium
Staining Solution
Liquid Chromatography Carrier
Ultra Pure Wash Water
Raw Protein Solution
Cleaning Solution
Developer
Fixer
Biocide/Disinfectant
Quench Solution
Burn Catalytic and
Suppressant Compounds
Polishing Solution
Monomer Solution

GASES

MONATOMIC, DIATOMIC, AND LIGHT GASES

O_2	He
N_2	Ar
H_2	H_2O
CO_2	Xe
CO	

OTHER GASES

Light Hydrocarbons
Halogens:
- Cl_2
- F_2

Freon 22
Freon 113
Organic Vapors
Halon

Unrecoverable Liquid Waste Storage

Liquid waste will consist of both organic and inorganic solvents, acids, bases, buffer solutions, and etchants with the majority of the liquid waste as water. The waste liquid, once separated from the gas stream will be pumped by the output pressure of the gas/liquid separator to a storage tank. The storage tank will be a 13.8 inch I.D. spherical tank. The outter structure will be aluminum with a Teflon lining. Also a butyl rubber bladder and a pressure port on the dry side of the bladder will enable waste liquid discharge and ground refurbishment. When the tank has reached its storage capacity it will be removed by the crew and transferred to the logistics module and replaced with an empty tank. Provisions must be made in the logistics module to accommodate the waste liquid quantities.

Water recovery from these waste fluid mixtures reduces the weight and cost of de-orbiting waste fluid quantities. There are several candidate facilities for waste water recovery including the Continuous Flow Electrophoresis (CFE), Protein Crystal Growth, Solution Crystal Growth, Organic and Polymer Crystal Growth and Isoelectric Focusing. The water recovery system presented in Figure 1.3-7 will be included in the water supply concept to illustrate how the systems will be integrated. User equipment which meets recoverable water standards will be connected to the system through a 3/8 inch waste line. At the point of leaving the multifiltration unit, the water will be pure enough to be mixed in with the main supply water for processing and delivery back to the users.

Gaseous Waste Handling

A major function of the PMMS will be the disposition of USL waste gases. Due to recent tightening of external contamination requirements, continuous venting from the waste handling system was restricted. As a result, the Waste Gas Handling System (WGHS) will be designed to store all waste gases generated by USL payloads for a 14 day period. This requirement was devised to accommodate the external attached payload's viewing clarity and duration.

Compatible gases will be transferred into the integrated waste fluid system at ambient temperatures and pressures ranging from .005 to 14.7 psia through a two-inch interface. As shown in Figure 1.3-5 unburned combustibles, from combustion experiments, air and inert gases are all dumped into a waste gas vacuum vent line. To minimize the possibility of a combustion reaction taking place in the WGHS vent lines and storage tanks, oxidizers and fuels will be segregated at their source.

Gas phase chemical reactions in the transfer line could result in potential hazards. Potential reactants from specified fuels and oxidizers and possible reaction avoidance methodology is presented in Table 1.3-6.

Waste fluids which are determined to be compatible with the Integrated Waste Fluid System (IWFS) will be delivered through dedicated lines. The PMMS will provide the necessary vacuum pumps, and safing hardware as required for delivery of safe low pressure gases to the IWFS. The IWFS will be responsible for gas compression, storage and disposal. Waste gases that are incompatible with the IWFS and that cannot be vented will be stored until deorbited in the Shuttle.

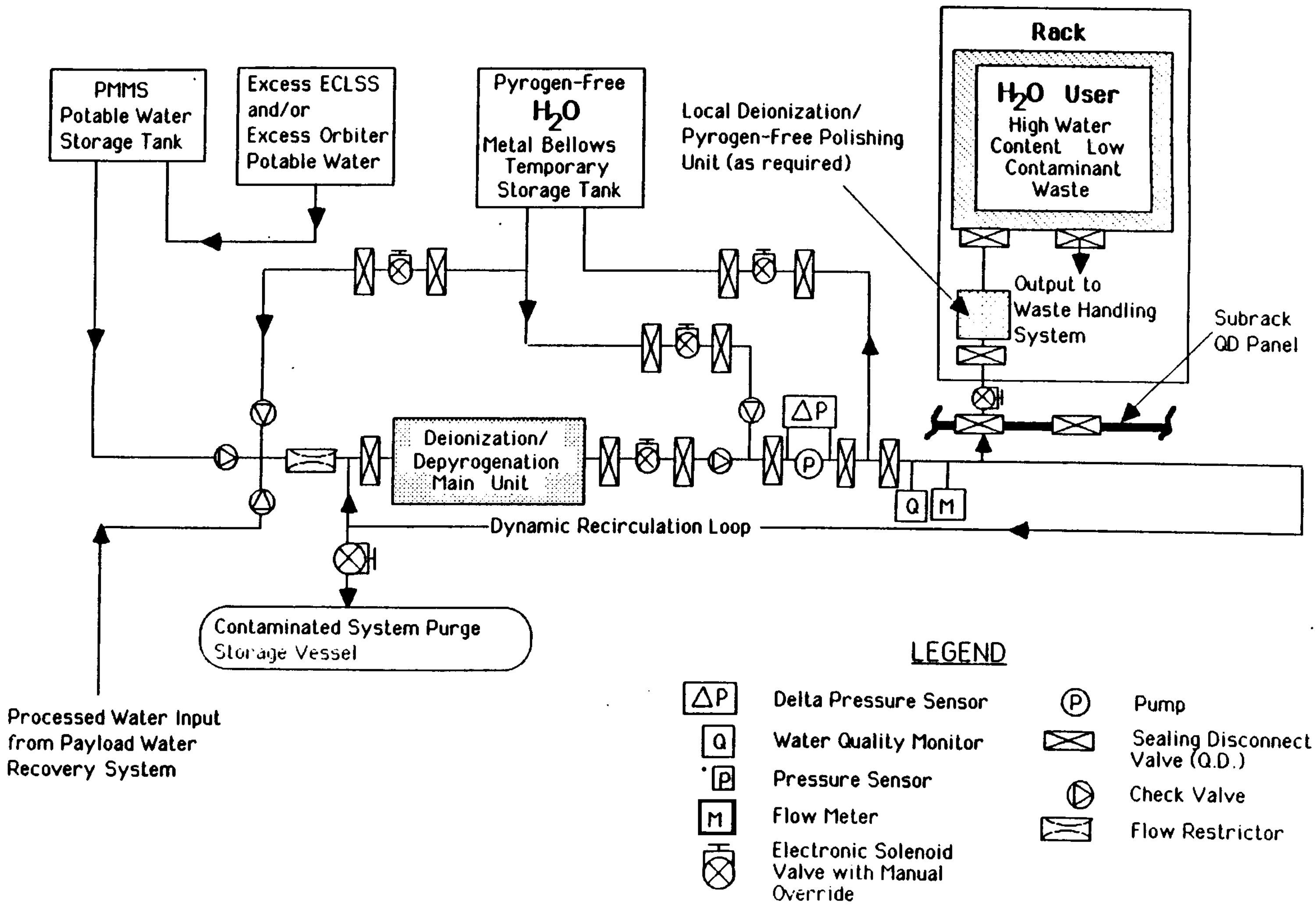

Figure 1.3-7 PMMS Water Supply and Recovery System

Table 1.3-6 Potential Gas Phase Chemical Reactions in a Common Vent Line

Potential Chemical Reaction Type	Reactants		Reaction Avoidance Methodology
	Fuels	**Oxidizers**	
Combustion	H_2 CO Aliphatic Organics (e.g., Acetylene) Aromatic Organics (e.g. Toluene)	O_2 H_2O_2 (Hydrogen Peroxide)	Timeline venting for common vent line configuration. Segregation of fuels and oxidizers.
	Acid Vapors	**Caustics**	
Neutralization	HNO_3 HF HCL	NaOH KOH	Timeline venting of incompatible payload gases. Negligible gas quantities or normally liquid etchants. Utilize operational constraints to avoid mixing.
	Halogens	**Hydrocarbons & Metals**	
Halogenation	Cl_2 F_2	Aliphatic Organics (e.g., Acetylene) Aromatic Organics (e.g., Toluene) Cadmium Tellurium Aluminum Berylium	Timeline venting for common vent line configuration. Utilize effective particulate filtration. Segregation of halogens (oxidizer line) and organics (fuel line).

1.3-4 Vacuum Vent System

The function of the USL experiment vacuum vent system is to maintain a high quality resource for the USL user community. Experiment chamber purge and waste dump functions are the responsibility of the USL Process Material Management System (PMMS) and are not to be confused with the high quality vacuum vent system.

Figure 1.3-8 shows the vacuum vent system design concept in a cutaway view of the USL module.

The USL experiment vacuum vent will provide the user with a 10^{-3} torr standard vacuum resource. A higher quality vacuum may be obtained by augmenting the system with user provided turbomolecular pumps located in the racks where necessary.

Only small amounts of the waste fluids discussed in Section 1.3.3.2 will be vented to purge experimental chambers. The present design vent rate is approximately .004 ft^3/h at pressures ranging from .25 torr to nearly vacuum. As venting constraints become more severe the quantities and types of fluids being vented will need to be reevaluated.

A components list of the vacuum vent system is provided in Table 1.3-7.

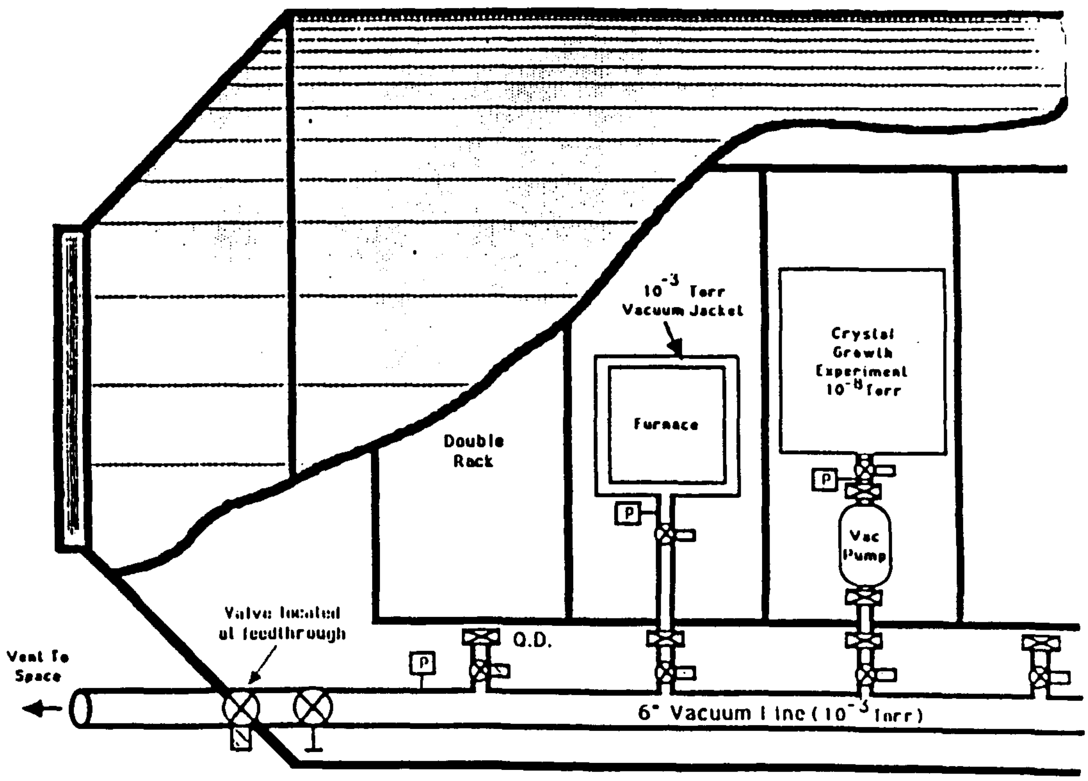

Figure 1.3-8 Experiment Vacuum Vent System Design Concept

Table 1.3-7 Vacuum Vent System Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
3	USL,VVS	DISCONNECT,	22	2	.25 (TORR)	ALL	1.45	TBD	TBD
1	USL,VVS	SENSOR, PRESSURE	2	6.	.25 (TORR)	ALL	1.95	TBD	TBD
2	USL,VVS	VALVE, MANUAL SHUTOFF	22	2	.25 (TORR)	ALL	1.42	TBD	TBD
5	USL,VVS	VALVE, MANUAL SHUTOFF	2	6	.25 (TORR)	ALL	0.7	TBD	TBD
4	USL,VVS	VALVE, SOLENOID	4	6	.25 (TORR)	ALL	15.0	TBD	TBD

1.4 UNITED STATES LABORATORY REFERENCES

1) Peterson, T., Space Station Fluid Inventories of the Integrated Waste Fluid and Integrated Water Systems, PIR No. 191. NASA Lewis Research Center, Cleveland, OH, March 1987.

2) Space Station Definition and Preliminary Design, WP-01, Book 3 US Lab Module, SSP-MMC-00031, Rev. B, NAS8-36525. Martin Marietta Denver Aerospace, Denver, CO, Oct. 31, 1986.

3) Fluids Technical Integration Panel Data, Presented at Marshall Spaceflight Center, Huntsville, AL, October 1986.

2.0 HABITATION MODULE AND AIRLOCKS

2.1 HABITATION MODULE AND AIRLOCKS OVERALL REQUIREMENTS

The Habitation Module will be a common module outfitted for use as the Space Station (SS) crew living quarters. The airlocks will be nodes which allow for Extra-vehicular Activity (EVA) operations.

2.2 HABITATION MODULE AND AIRLOCKS FLUID SYSTEMS REQUIREMENTS

The current IOC for SS calls for use of two airlocks, one access airlock and one hyperbaric airlock. The access airlock must pump up to 90% of the usable air back into the Space Station before venting the remainder of the air to space. The pumping system that does this is considered part of the structures work package and has no fluid requirements of its own. The hyperbaric airlock has the same requirements as the access airlock and additionally must be capable of maintaining structural integrity up to six atmospheres for repressurization of personnel injured due to a damaged Extra-vehicular Excursion Unit (EEU) during EVA operations. The fluid system requirements for hyperbaric operations and the safe-haven operations are both covered in the ECLSS section. As such, the Habitation Module and Airlocks have no unique fluid system requirements which are not covered by the Integrated Systems. For detailed fluid requirements refer to the appropriate section in the system write-ups as follows:

Section 6.0 Integrated Waste Fluid System (IWFS)
Section 7.0 Integrated Water System (IWS)
Section 8.0 Integrated Nitrogen System (INS)
Section 9.0 Environmental Control and Life Support System (ECLSS)
Section 10.0 Thermal Control System (TCS)

2.3 HABITATION MODULE AND AIRLOCKS FLUID SYSTEMS DESCRIPTIONS AND CONFIGURATIONS

Fluid system descriptions and configurations for the Habitation Module, access airlock and hyperbaric airlock have been included in the following sections:

Section 6.0 Integrated Waste Fluid System
Section 7.0 Integrated Water System
Section 8.0 Integrated Nitrogen System
Section 9.0 Environmental Control and Life Support System
Section 10.0 Thermal Control System

2.4 HABITATION MODULE AND AIRLOCKS REFERENCES

1) Space Station Definition and Preliminary Design, WP-01, Book 2, SSP-MMC-00031, Rev. B, NAS8-36525. Martin Marietta Denver Aerospace, Denver, CO, October 31, 1986.

2) Space Station Definition and Preliminary Design, WP-01, Book 10 Airlocks, SSP-MMC-00031, Rev. B, NAS8-36525. Martin Marietta Denver Aerospace, Denver, CO, October 31, 1986.

3.0 LOGISTICS ELEMENTS

Logistics elements will be used for transporting the needed equipment, fluids, and raw materials to support Space Station crew and user operations. The logistics elements will also serve to transport experiment products and waste of all kinds back to earth. Two types of logistics elements have been defined as Pressurized Logistics Carriers (PLC's) and Unpressurized Logistics Carriers (ULC's) for carrying dry goods, fluids, and propellants. Both of these element types have been defined for transporting specific categories of logistics resupply items.

The PLC's will transport items for crew, station or user resupply which are to be used inside the pressurized environment. The PLC will be launched in the NSTS shuttle cargo bay and will be docked to one of the interconnecting nodes on the Space Station. This will allow "shirt sleeve" access to the PLC's payload from the other Space Station modules.

The ULC's are also launched in the shuttle, but they will transport goods and equipment to the Space Station for use outside the pressurized environment. Dry goods will be transported on dry goods pallets, which can be removed from the ULC and docked at locations outside the pressurized environment. The goods are removed from the pallet as necessary and transferred to Space Station experiments or subsystems located outside the pressurized modules.

The ULC's will also transport necessary fluids to the Space Station and other fluids users in the Space Station architecture. The fluids are transported to the Space Station on fluids pallets in much the same way as the dry goods are transported. The fluids pallets will be connected with umbilicals to the proper user subsystem or experiment. In the event that propellants must be supplied to users, additional fluids pallets will be constructed and designated as propellant pallets.

3.1 LOGISTICS ELEMENTS OVERALL REQUIREMENTS

The logistics elements will consist of several independent cargo transport vehicles designed for use with the other Space Station elements. They will provide a means for securing cargo within the NSTS Shuttle and for storing the same cargo before and after use on the Space Station structure. The Pressurized Logistics Carrier (PLC) will provide a means for resupplying internal Space Station crew and experiment supplies without the use of airlock or space suits.

The Unpressurized Logistics Carriers (ULC's) will allow transport of goods and materials that will be used outside the pressurized environment or fluids that will be transferred to internal systems through umbilical connections. The use of the UPC's with no pressure shell provides a means for cutting down the mass of structure which must be launched in the shuttle.

The overall requirements for the Logistics Elements are presented in Table 3.1-1.

Table 3.1-1 Overall Requirements for the Logistics Elements

1) The logistics elements must resupply consumables to the Space Station every 90 days.

2) The logistics elements shall remain operational for a minimum of 10 years or 40 flights.

3) The logistics elements shall provide a 50" by 50" hatch with 12" radius corners to accommodate transfer of equipment between modules.

4) The weight of logistics elements shall be kept to a minimum.

5) The logistics elements shall provide a pressurized volume.

6) The logistics elements shall provide facilities for storing supplies, spares, equipment an fluids to support Space Station and users.

3.2 LOGISTICS ELEMENTS FLUID SYSTEMS REQUIREMENTS

Fluid system requirements for the logistics elements are presented in Table 3.2-1.

Table 3.2-1 Logistics Elements Fluid System Requirements

Element	Requirements
Environmental Control and Life Support System for PLC	1) Provide temperature and humidity control. 2) Provide atmospheric control and supply. 3) Provide atmosphere revitalization. 4) Provide fire detection and suppression. 5) Provide resupply and return of consumables and orbital replacement unit elements for other functions within the Space Station Program.
Fluid Resupply Pallets	1) Provide capability to unload, distribute, and dispose of all fluids necessary for Space Station operations, crew support, and user support. 2) Some Japanese Experimental Module fluids will be supplied by the Experimental Logistics Module.

3.3 LOGISTICS ELEMENTS FLUID SYSTEMS DESCRIPTIONS AND CONFIGURATIONS

The descriptions and configurations of the Logistics Elements vary greatly with the size and number of experiments on Space Station, the size of the crew, and the venting requirements imposed on disposal systems. The fluids requirements imposed on the Logistics Elements are directly related to these configurations. The data presented in Table 3.3-1 is extracted from Fluids

Technical Interchange Panel data dated 15 August 1986. The configurations presented are no longer correct; i.e., Space Station propulsion no longer requires hydrazine. However, this is the latest tabulation of logistics requirements available. When new data becomes available it will be added to this database.

Table 3.3-1 Logistics Elements Delivery and Return Requirements

Fluid User	Fluid	Requirement (Purpose)	Mass Up (lbm)	Mass Down (lbm)	Volume Up (cu. ft.)	Volume Down (cu. ft.)	Logistics Element	Remarks
ECLSS	O2	Module repress.	444	444	24.8	24.8	TBD	Contingency only. Not every 90 days.
ECLSS	O2	Hyperbaric chamber	622	622	34.8	34.8	TBD	Contingency only. Not every 90 days.
ECLSS	N2	Module repress.	1,396	1,396	27.6	27.6	TBD	Contingency only. Not every 90 days.
ECLSS	N2	Hyperbaric chamber	1,272	1,272	25.2	25.2	TBD	Contingency only. Not every 90 days.
ECLSS	N2	Leakage makeup	1,368	-	27.2	-	Fluids Pallet	
ECLSS	N2	MMU operations	1,144	-	19.6	-	Fluids Pallet	
ECLSS	N2	Airlock repress.	668	-	15.2	-	Fluids Pallet	
ECLSS	H2O	Waste	-	1,750	-	28.0	PLC*	
Station	N2H4	Propellant	5,000	-	80.0	-	Propellant Pallet	No longer a requirement but incl. in 8/86 data.
USL	H2O	Materials processing	1,400	-	22.4	-	Fluids Pallet	Assumes 75% recycling and CFES
USL	N2	Materials processing	1,256	-	21.2	-	Fluids Pallet	
USL	Ar	Materials processing	224	-	7.6	-	Fluids Pallet	
USL	O2	Materials processing	80	-	4.4	-	Fluids Pallet	
USL	He	Materials processing	16	-	0.8	-	Fluids Pallet	
USL	Cleaning Fl.	Mat. process. cleanup	128	-	1.8	-	PLC	No information on fluid constituents.
Columbus	Multiple	Lab resupply	14,712	14,712	568.0	568.0	PLC	Volume estimated. These are the only quantities supplied for fluids and all other materials. There is no current breakdown of individual fluids.
JEM	H2O	Life sciences	240	-	4.0	-	PLC	
JEM	N2	Life sciences	44	-	5.0	-	PLC	
JEM	Multiple	Materials processing	TBD	TBD	TBD	TBD	PLC,Fluids Pallet	JEM will have materials processing experiments. Most resupply will be done by ELM but there may be additional logistics elements requirements.
Customer Serv.	N2H4	Propellant resupply	14,830	-	237.0	-	Propellant Pallet	Includes Spartan, GRO, COP. These requirements may be obsolete.

* Pressurized Logistics Carrier

3.3.1 Pressurized Logistics Carrier Fluid Systems

3.3.1.1 Environmental Control and Life Support System

Temperature and Humidity Control (THC)

The temperature and humidity of the atmosphere and other equipment will be controlled within the PLC. These control functions will provide ventilation throughout all areas of the PLC. The heat collected will be transferred to the Thermal Control System for dissipation. Specialized equipment (refrigerators/freezers) will also dissipate their waste heat to the Thermal Control System.

Atmosphere Control and Supply (ACS)

Atmosphere pressure and composition control functions will provide for monitoring and regulating the partial and total pressure of oxygen and nitrogen in the PLC atmosphere. Vent and relief pressure functions will also be provided along with the distribution and storage of O_2 and N_2 for the PLC, and the resupply of N_2.

Atmosphere Revitalization (AR)

Monitoring of atmospheric constituents and control of particulates and bacteria will be provided.

Fire Detection and Suppression (FDS)

Fire detection and suppression equipment will be provided for the pressurized volume with both fixed and portable extinguishers and emergency portable breathing equipment as required.

Resupply/Return

Resupply consumables and emergency provisions for the entire Space Station Program ECLSS will be provided. Tankage for H_2O is located in the PLC. Replacement kits/ORU's for all ECLSS functions will be included such as filters, wipes, and water treatment resupply. Waste return will also be provided for waste water (brine), fecal material, trash, and carbon filters.

Additional information on the Space Station ECLSS can be found in Section 9.0 of this document.

3.3.1.2 Laboratory Process Fluids Rack

Resupply of process fluids for the U.S. Laboratory (USL) will consist of fluids racks carried internally in the Pressurized Logistics Carrier. The racks may be transported in the Unpressurized Logistics Carrier (ULC), but this require the use of an airlock to have the rack inside. The requirements for process fluids vary greatly with the number and type of experiments on board. As the requirements are further developed, the configuration of the laboratory process fluids racks will be better defined. The laboratory process fluids configuration equipment list is TBD.

3.3.2 Unpressurized Logistics Carrier Fluid Systems

3.3.2.1. Fluids Pallet - The fluids pallet will be configured to transport fluids other than propellants to the Space Station. One fluids pallet configuration will be used to transport nitrogen in to the station for resupply of the ECLSS system by means of the integrated nitrogen distribution system. The logistics of resupplying nitrogen to the space station program is discussed in Section 8.0 of this report. A second configuration may be used to resupply U.S. Laboratory (USL) process fluids when the USL fluids racks are transported in the Unpressurized Logistics Carrier (ULC).

The resupply of propellants will be accomplished with the Orbital Spacecraft Consumable Resupply System as discussed in Section 12.0 of this report.

3.4 LOGISTICS ELEMENTS REFERENCES

1) Fluids Technical Integrated Panel, presented at Marshall Space Flight Center, Huntsville, AL, October, 1986.

2) Space Station Definition and Preliminary Design, WP-01, Book 4 - Logistics Module. SSP-MMC-00031 (Rev. B). Martin Marietta Denver Aerospace, October, 1986. (Contract NAS8-26525).

4.0 JAPANESE EXPERIMENTAL MODULE (JEM)

The Japanese Experimental Module (JEM) will be a Japanese built and outfitted laboratory module which will be part of the permanent Space Station. This module, funded by the National Space Development Agency of Japan (NASDA), will give the Japanese the capability to run their own experiments in microgravity environments and will permit them to conduct them in privacy by closing the hatch between modules. The JEM will house both life sciences and materials processing experiments, some of which are considered proprietary by NASDA. The privacy provided by a closed hatch will allow the Japanese to keep this information to themselves.

The Japanese Experimental Module will be supplemented by the Experiment Logistics Module (ELM), another NASDA element of the Space Station architecture. The ELM is a small replaceable module that will carry supplies needed by the JEM but not necessarily available from the core station or carried on the Logistics Module. The ELM will be transported by the NSTS Shuttle and docked to the JEM. The ELM will be considered a part of the JEM for this discussion.

4.1 JAPANESE EXPERIMENTAL MODULE OVERALL REQUIREMENTS

The JEM is a multidiscipline facility for payload accommodation both within a pressurized habitable volume and outside, exposed to space. The principal functions of the JEM include materials research and development that is sensitive to acceleration, research in life sciences relating to the behavior and adaptation to long term exposure to extremely low acceleration levels, and observation of the effects of exposure to space.

The overall requirements for the Japanese Experimental Module (JEM) are presented in Table 4.1-1.

Table 4.1-1 Overall Requirements for JEM

1) Accommodate the performance of selected complements of experiments both in a pressurized volume and exposed to space.
2) Provide cooling of TBD kW.
3) Provide for isolated operations during proprietary experiments.
4) Provide a process fluids system.
5) Provide a vacuum vent system.
6) Provide a waste management system.
7) Provide airlock operations to allow access to exposed facilities and external payloads.
8) Provide storage and transport capabilities with the Experimental Logistics Module (ELM).

4.2 JAPANESE EXPERIMENTAL MODULE FLUID SYSTEMS REQUIREMENTS

Fluid resupply and disposal requirements for the JEM are provided in Table 4.2-1 and fluid system requirements are provided in Table 4.2-2.

Table 4.2-1 JEM Fluid Resupply and Disposal Requirements

Fluid Types	Resupply Requirement
N_2, O_2, Air, Water	Supplied by Space Station Core through docking port transfer lines.
Water, Freon	Supplied by JEM ELM for Thermal control.
Ar, Dry Air, He, Kr, CO_2	Supplied by JEM ELM for material processing and life science experiment gases from common gas supply unit.
H_2, O_2, C_3H_8, NH_3, CL_2, SiH_4	Supplied by JEM ELM for material processing and life sciences experiment from gas supply units integrated inside the experiment equipment as mission peculiar.
Water	Supplied by JEM ELM for life sciences water to be supplied in cartridges.
C_3H_8, NH_3, CL_2, SiH_4, NH_4Cl, HCL, H_2O	Disposed of using the JEM ELM.

Table 4.2-2 Fluid System Requirements for the JEM

Fluid System	Fluid System Requirements
Environmental Control and Life Support System	1) Provide atmospheric pressure and composition control. a) Primary control will be monitored and maintained by Space Station Core. - Partial pressure oxygen: 2.83 psia to 3.35 psia. - Total pressure: 14.7 to 0.2 psia. b) Secondary control and control during closed hatch operations will be monitored and maintained by JEM with gases supplied by SS core and ECLSS. 2) Provide temperature and humidity maintenance. a) Primary control will be maintained by Space Station Core ECLSS. - Nominal temperature range will be 65°F to 80°F. b) Secondary control and control during closed hatch operations will be monitored and maintained by JEM.

Table 4.2-2 Fluid System Requirements for the JEM (Continued)

Environmental Control and Life Support System	3) Provide atmospheric revitalization. a) Primary revitalization duties will be performed by Space Station core ECLSS. - Regenerate module atmosphere to provide a safe and habitable environment for the crew using intermodule ventilation. - Primary source of oxygen is electrolysis of recovered water. - Nitrogen supply provided by storage and resupply. - Removal and processing of CO_2 will be accomplished through a regenerative process. b) Secondary revitalization and closed hatch revitalization. - Oxygen and nitrogen will be transferred from Space Station with emergency storage in bottles. - CO_2 will be removed in JEM and transferred to the Space Station for reduction. 4) Provide water and waste management. a) Primary water supply and waste management is performed by Space Station core ECLSS. - Collect, process, and dispense potable and hygiene water to meet crew and experimental needs. - Ensure proper water quality through pretreatment and post treatment. Trace gas analyzer line provided. - Provide a closed-loop recovery system for drinking water. b) Secondary water supply and waste functions are performed by JEM ECLSS. - Potable and hygiene water from Space Station ECLSS are dispensed by JEM. - Eyewash and handwash water and condensate is returned to Space Station waste water recovery. 5) Provide thermal control for module and experiments. a) Coolant water is recycled within Thermal Control System. b) Freon is recycled within Thermal Control System. 6) Provide fire detection and suppression.

Table 4.2-2 Fluid System Requirements for the JEM (Continued)

Mission Fluids System Requirements (Including Fluid Storage, Supply Disposal and Vacuum Vent System	1) Material Processing Fluids a) Provide storage and distribution of JEM material processing fluids. b) Provide safe handling, removal, storage, and disposal of JEM payload waste by-products. c) Provide a minimum of 1×10^{-2} torr vacuum pressure for waste gas removal from all JEM internal payloads. d) Prevent overall Space Station dump rate from exceeding TBD sccf. e) Prevent disturbances to microgravity research throughout the Space Station. f) Comply with Space Station external contamination constraints. If vented; will be non-propulsive. g) Interface with Space Station IFMS. h) Capable of storing all non-FMS compatible gases for a minimum of 90 days if fluid does not meet contamination requirements. 2) Life Sciences Experiment Fluids a) Provide all life sustaining fluids to plant and animal life in the JEM. b) Provide for removal and disposal of plant and animal waste.

4.3 JAPANESE EXPERIMENTAL MODULE FLUID SYSTEMS DESCRIPTIONS AND CONFIGURATIONS

4.3.1 Housekeeping Fluids System

The JEM Housekeeping Fluids System will combine the tasks of Environmental Control and Life Support, Thermal Control, and Fire Detection and Suppression. Any fluids that are not used for experiments will be included in Housekeeping Fluids. The housekeeping fluids system will consist of the six main subsystems as described below:

a) Temperature and Humidity Control (ECLSS)

1) Cabin air temperature and humidity
2) Ventilation
3) Equipment air cooling

b) Atmosphere Control and Supply (ECLSS)

1) O_2/N_2 pressure control (total and partial) during closed hatch operations
2) Vent and Relief
3) O_2/N_2 storage and distribution for closed hatch and emergency operations

c) Atmosphere Revitalization (ECLSS)

1) CO_2 removal
2) CO_2 sent to Space Station ECLSS for reduction
3) O_2 supplied by electrolysis in Space Station core ECLSS
4) Contaminant control
5) Contaminant monitoring

d) Water Recovery and Management (ECLSS)

1) Condensate water returned to Space Station ECLSS for processing
2) Hygiene water returned to Space Station ECLSS for processing
3) Water distribution

   - hygiene water to hand washer
   - potable water to eye wash

e) Fire Detection and Suppression

1) Fire detection
2) Fire suppression
3) Crew protection

f) Thermal Control

1) Cooling of experiments up to TBD kW, using water and freon cooling loops.
2) Passive thermal control of JEM module by multilayer insulation (MLI) and thermal coatings.

Figure 4.3-1 shows a schematic diagram of the Environmental Control and Life Support Subsystem of the JEM and its interfaces with the Space Station and ELM. Figure 4.3-2 shows a schematic diagram of the Thermal Control System for the JEM. Tables 4.3-1 and 4.3-2 provide fluids requirements for the Housekeeping Fluids System.

After use by the Housekeeping System, Housekeeping Fluids will either be returned to the Space Station ECLSS for reprocessing or, in the case of battery leakage fluids, (N_2,O_2,H_2) will be vented to space. The latter occurs only under emergency conditions.

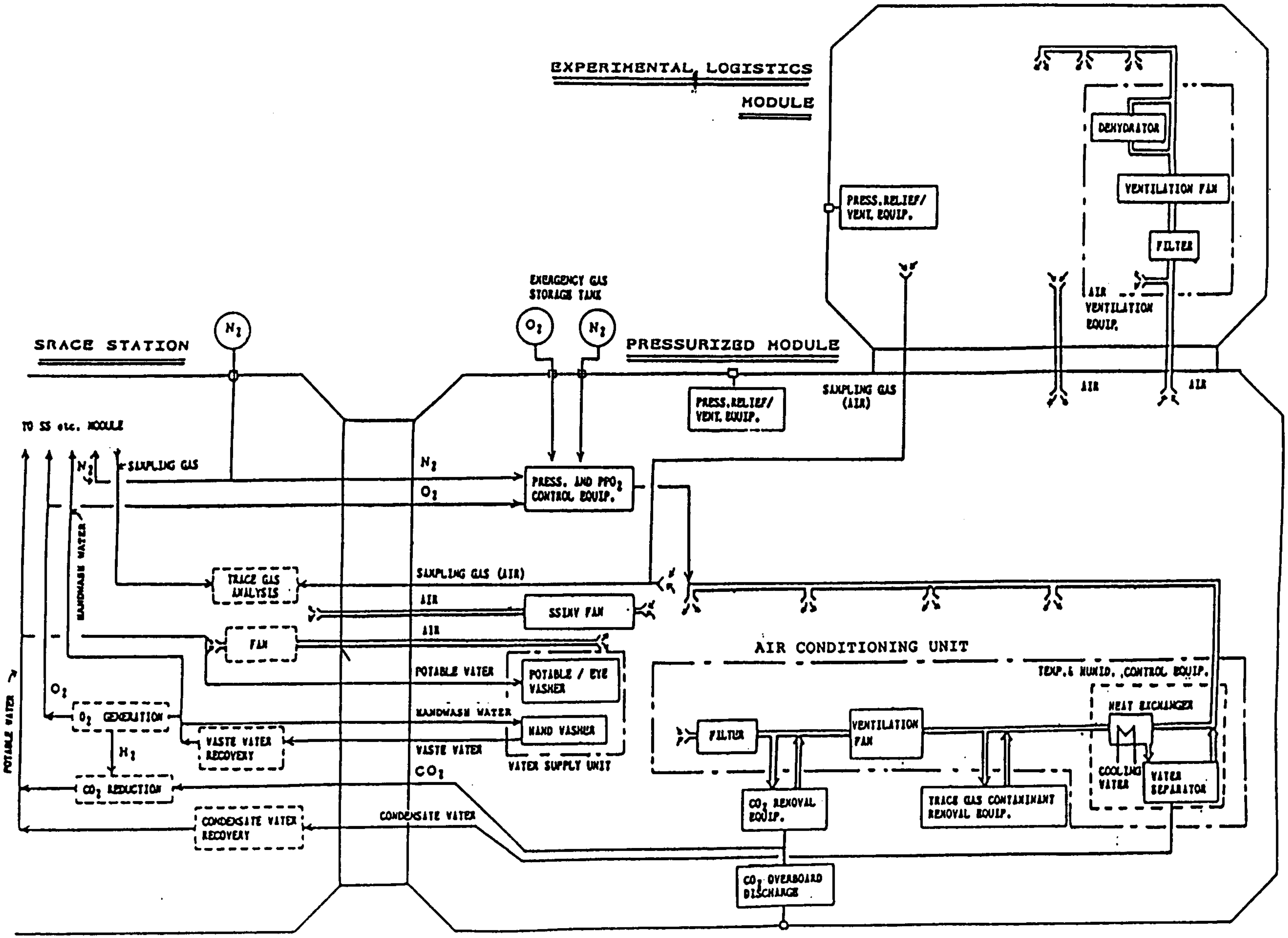

Figure 4.3-1 JEM ECLSS Schematic

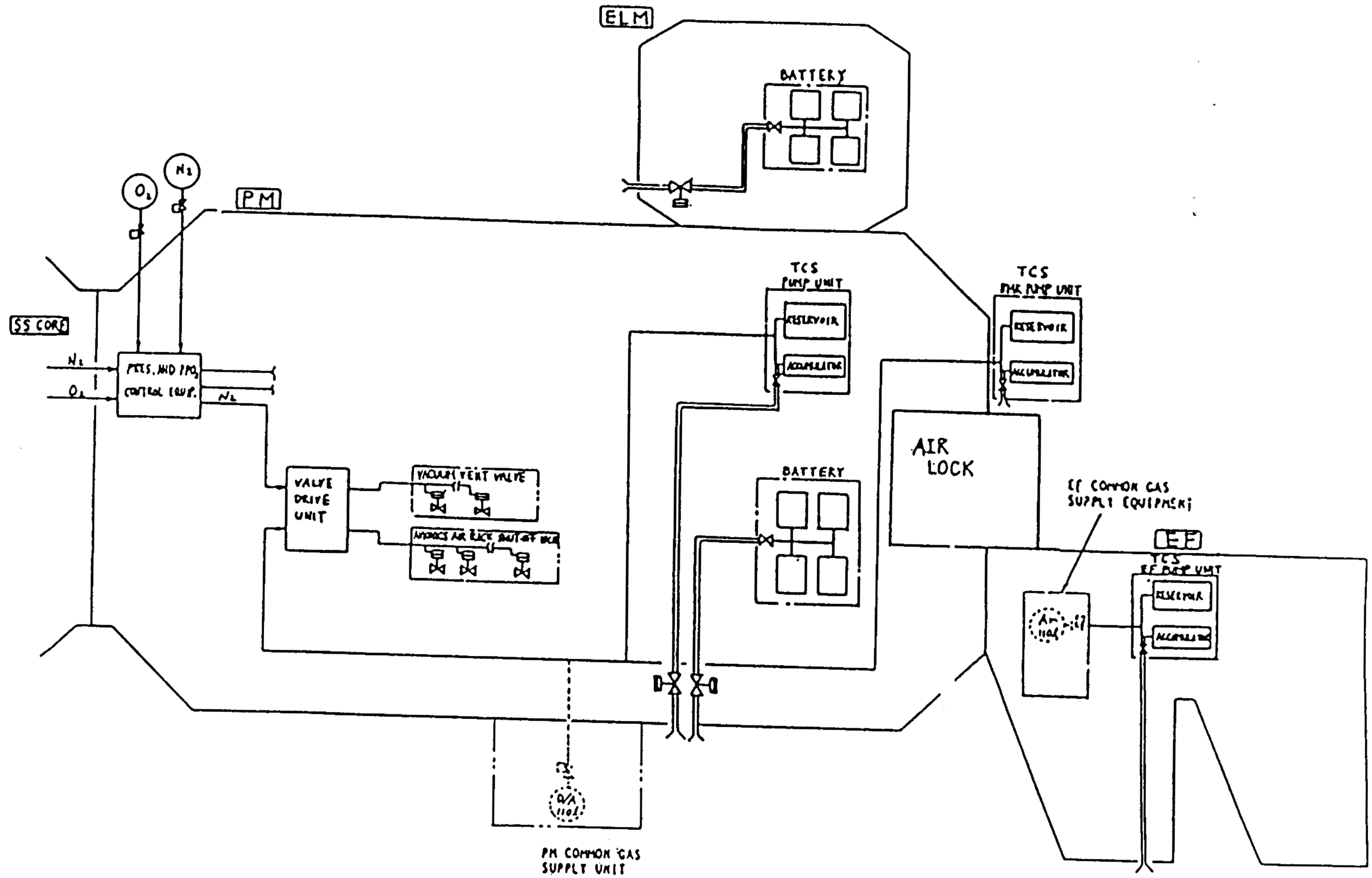

Figure 4.3-2 Thermal Control System and Emergency Battery Vent

Table 4.3-1 Fluid Inventory Requirements for the JEM Housekeeping Fluid System

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS)		RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
						MEAN	MAX			
35	JEM	HOUSEKEEPING	H2O	TBD	TBD	368	TBD	PIPED FROM SS CORE ECLSS	POTABLE	POTABLE WATER IS USED FOR ECLSS FUNCTIONS
36	JEM	HOUSEKEEPING	H2O	TBD	TBD	359	TBD	PIPED FROM SS ECLSS	HYGIENE WATER	HYGIENE WATER IS USED FOR ECLSS FUNCTIONS.
37	JEM	HOUSEKEEPING	H2O	66	0 NOM	TBD	TBD	JEM ELM	COOLANT ONLY	RECYCLED WITHIN TCS. RESUPPLY IS ONLY FOR CONTINGENCY REFILL OF COOLANT.
38	JEM	HOUSEKEEPING	FREON	88	0 NOM	TBD	TBD	JEM ELM	TBD	FREON IS USED FOR REFRIGERATION.
39	JEM	HOUSEKEEPING	AIR	TBD	100-220 CU M/HR	TBD	TBD	RECYCLED BY ECLSS	TBD	AIR IS USED FOR VENTILATION AND BREATHING.
40	JEM	HOUSEKEEPING	GO2	TBD	TBD	37.2	TBD	PIPED FROM ECLSS	TBD	OXYGEN IS MIXED WITH NITROGEN DURING CLOSED HATCH OPS TO PROVIDE ATMOSPHERE FOR BREATHING.
41	JEM	HOUSEKEEPING	GN2	TBD	TBD	14	TBD	PIPED FROM SS ECLSS	TBD	N2 USED FOR MIXING WITH O2 DURING CLOSED HATCH OPS TO PROVIDE BREATHABLE ATMOSPHERE
42	JEM	HOUSEKEEPING WASTE	H2O	TBD	TBD	450	TBD	CONDENSED FROM ATMOSPHERE	TBD	WATER IS CONDENSED FROM ATMOSPHERE. PRESENT DUE TO RESPIRATION, PERSPIRATION.
43	JEM	HOUSEKEEPING WASTE	H2O	TBD	TBD	272	TBD	WASTE WASH WATER	HYGIENE WATER	HYGIENE WASTE WATER IS COLLECTED AND RETURNED TO SS ECLSS
44	JEM	HOUSEKEEPING WASTE	CO2	TBD	TBD	40	TBD	BYPRODUCT OF RESPIRATION	TBD	CO2 IS REMOVED FROM ATMOSPHERE AND RETURNED TO SS ECLSS THROUGH PIPING.
45	JEM	HOUSEKEEPING WASTE	AIR	TBD	100-220 CU M/HR	TBD	TBD	CABIN VENTILATION	TBD	CABIN AIR IS DUCTED BACK TO SS ECLSS FOR PROCESSING.
46	JEM	HOUSEKEEPING WASTE	AIR	TBD	TBD	115	TBD	SS ECLSS	TBD	AIR IS FOR RESUPPLY OF THAT LOST TO SPACE BY LEAKAGE, AIR LOCK AND DOCKING PORT USE ONLY.
47	JEM	HOUSEKEEPING WASTE	AIR/GN2	TBD	TBD	.22	TBD	SS ECLSS	TBD	USED ONLY FOR MAKEUP OF TCS MAINTENANCE AND COOLANT RESUPPLY GASES LOST TO SPACE
48	JEM	HOUSEKEEPING WASTE	GN2	TBD	TBD TBD	TBD	TBD	SS ECLSS	TBD	EMERGENCY VENT FROM BATTERY CELL CHAMBER

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Table 4.3-2 Fluid Interface Requirements for the JEM Housekeeping Fluid System

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	INLET AND OUTLET FLUID CONDITIONS: FROM / TO	PRESSURE (PSIA)	TEMP. (F)	LINE SIZES (INCHES)	METHOD OF WASTE MANAGEMENT	FAILURE TOLERANCE	REMARKS
35	JEM	HOUSEKEEPING	H2O	SS ECLSS CREW, USERS	TBD TBD	TBD TBD	TBD TBD	RETURN TO ECLSS THRU PLUMBING	TBD	ALL WASTE WATER PROCESSING IS DONE BY SS CORE ECLSS.
36	JEM	HOUSEKEEPING	H2O	SS ECLSS CREW, USERS	TBD TBD	TBD TBD	TBD TBD	RETURN TO ECLSS THRU PLUMBING	TBD	ALL WASTE WATER PROCESSING IS DONE BY SS CORE ECLSS.
37	JEM	HOUSEKEEPING	H2O	JEM RESUPPLY (ELM) LEAKAGE	TBD TBD	TBD TBD	TBD NONE	LEAKAGE ONLY	TBD	WATER IS ONLY FOR LEAKAGE MAKEUP. RESUPPLY IS ONLY FOR QUANTITY REQUIRED WHEN REQUIRED.
38	JEM	HOUSEKEEPING	FREON	JEM ELM RESUPPLY LEAKAGE, PURGE	TBD TBD	TBD TBD	TBD TBD	PURGE TO TANK FOR DEORIT	TBD	FREON IS ONLY PUGED FOR DERBIT OR LEAKED OUT. RESUPPLY IS ONLY FOR CONTINGENCY.
39	JEM	HOUSEKEEPING	AIR	SS ECLSS CABIN VENTILATION	TBD TBD	TBD TBD	TBD TBD	RETURN TO ECLSS THRU PLUMBING	TBD	AIR IS REVITALIZED BY SS CORE ECLSS (SCRUBBING, CO2 REDUCTION) AND RECYCLED.
40	JEM	HOUSEKEEPING	GO2	SS ECLSS CABIN AIR	TBD TBD	TBD TBD	TBD TBD	RETURN TO SS CORE ECLSS	TBD	O2 IS MIXED WIRH N2 ONLY FOR CLOSED HATCH OPS.
41	JEM	HOUSEKEEPING	GN2	SS ECLSS CABIN AIR	TBD TBD	TBD TBD	TBD TBD	RETURN TO SS CORE ECLSS	TBD	O2 IS MIXED WIRH N2 ONLY FOR CLOSED HATCH OPS.
42	JEM	HOUSEKEEPING WAST	H2O	CREW, USERS SS CORE ECLSS	TBD TBD	TBD TBD	TBD TBD	PIPED TO SS CORE ECLSS	TBD	ALL WASTE WATER PROCESSING IS DONE BY SS ECLSS
43	JEM	HOUSEKEEPING WAST	H2O	CREW, USERS SS ECLSS	TBD TBD	TBD TBD	TBD TBD	PIPED TO SS CORE ECLSS	TBD	HYGIENE WASTE COMES FROM WASH WATER ETC. IT IS RECYCLED BY SS ECLSS.
44	JEM	HOUSEKEEPING WAST	CO2	RESPIRATION SS ECLSS	TBD TBD	TBD TBD	TBD TBD	PIPED TO SS ECLSS	TBD	JEM ECLSS REMOVES CO2 FROM ATMOSPHERE. REDUCTION OCCURS IN SS ECLSS.
45	JEM	HOUSEKEEPING WAST	AIR	CABIN VENTILATION SS ECLSS	TBD TBD	TBD TBD	TBD TBD	RETURN TO SS CORE ECLSS	TBD	AIR IS REVITALIZED BY SS CORE ECLSS
46	JEM	HOUSEKEEPING WAST	AIR	CABIN VENTILATION SPACE	TBD TBD	TBD TBD	TBD TBD	LEAKAGE AND VENT TO SPACE	TBD	AIR MUST BE MADE UP WHEN LOST TO SPACE
47	JEM	HOUSEKEEPING WAST	AIR/GN2	SS ECLSS SPACE	TBD TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	AIR/N2 USED FOR MAINTENANCE AND COOLANT MAKEUP IN TCS
48	JEM	HOUSEKEEPING WAST	GN2	BATTERY CELL SPACE	TBD TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	EMERGENCY VENT ONLY FROM BATTERY CELL CHAMBER

4.3.2 Mission Fluids System

The JEM Mission Fluids System combines the tasks of Experiment Gas Supply, Gas and Vacuum Venting, and Experiment Water Supply and Waste Water Management. The following subsystems make up the Mission Fluids System:

a) Experiment Gas Supply

A schematic of the Experiment Gas Supply subsystem is shown in Figure 4.3-3, and its fluids requirements are shown in Tables 4.3-3 and 4.3-4. The Experiment Gas Supply subsystem will provide process fluids for the experiments which use common types of gas. There will actually be two pieces to the subsystem, one within the pressurized module for supplying those experiments operated in the shirtsleeve environment, and one that will provide fluids to the Exposed Facility Units outside the module.

The internal system will supply krypton, helium, argon, and dry air to the materials experiment racks from a payload module (PM) common gas supply unit. Carbon dioxide from the PM common gas supply unit will be supplied to the life science experiment racks as will be oxygen and nitrogen gases from the Space Station core.

The external system will supply helium and argon to the exposed facility units outside the JEM from separate exposed facility common gas supply equipment which will be enclosed in one of several interchangeable payload modules.

b) Gas and Vacuum Venting

The reference configuration of the gas and vacuum vent systems is shown in Figure 4.3-4 as designed by the NASDA. This diagram shows the waste gas and vacuum vent systems being vented to space. More recent studies have shown a concern that the constituents of waste fluids vented to the surrounding environment may exceed column density or deposition requirements. This concern creates a need for eliminating the waste fluids by a method other than on demand venting. There are several alternative ways of eliminating waste fluids including propulsively venting through resistojets on a continuous basis, storing the fluids for 14 days and then venting them to space at one time, or storing them and returning them to earth on the NSTS Shuttle. Previous studies indicate that the most effective method of disposal is to combine the waste fluids from all the Space Station elements into one integrated waste fluids system (IWFS). This system would then be used to dispose of all the fluids using the chosen method. This eliminates the problems associated with having several venting systems operated at different times by different users.

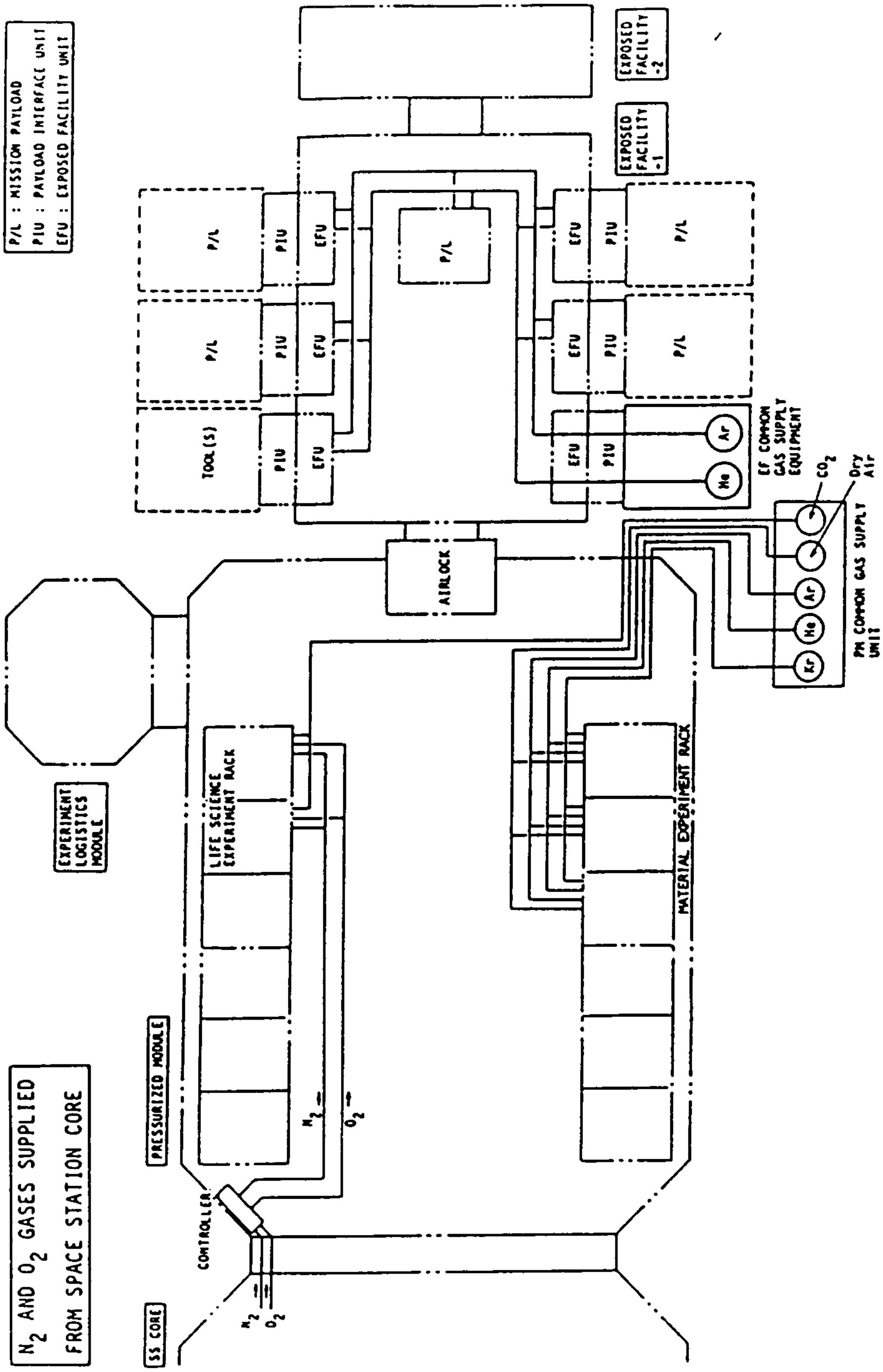

Figure 4.3-3 Experiment Gas Supply Schematic

Figure 4.3-3 Experiment Gas Supply Schematic

Table 4.3-3 JEM Experiment Supply and Disposal Fluid Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS)		RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
						MEAN	MAX			
49	JEM	EXPERIMENT FLUIDS	AIR	TBD	TBD	17.6	TBD	ELM	DRY AIR	USED FOR REACTIONS IN MATERIALS PROCESSING EXPERIMENTS. STABLE GAS
50	JEM	EXPERIMENT FLUIDS	Ar	TBD	TBD	151.8	TBD	ELM	TBD	USED FOR MATERIALS PROCESSING EXPERIMENT ATMOSPHERE PREPARATION. STABLE GAS. INERT
51	JEM	EXPERIMENT FLUIDS	Kr	TBD	TBD	9.9	TBD	ELM COMMON GAS SUPPLY	TBD	USED FOR MATERIALS PROCESSING EXPERIMENT ATMOSHPERE PREPARATION. STABLE GAS. INERT.
52	JEM	EXPERIMENT FLUIDS	GHe	TBD	TBD	4.4	TBD	ELM COMMON GAS SUPPLY	TBD	USED FOR MATERIALS PROCESSING EXPERIMENT COOLING. INERT
53	JEM	EXPERIMENT FLUIDS	GH2	TBD	TBD	.22	TBD	ELM TANK CHANGEOUT	TBD	USED AS REACTANT FOR MATERIALS PROCESSING EXPERIMENTS. REDUCER. EXPLOSIVE WITH O2 AND C12.
54	JEM	EXPERIMENT FLUIDS	GO2	TBD	TBD	3.3	TBD	SS CORE ECLSS	TBD	USED AS REACTANT IN MATERIALS PROCESSING. OXIDIZER. FLAMMABLE. EXPLOSIVE WITH PROPANE.
55	JEM	EXPERIMENT FLUIDS	PROPANE	TBD	TBD	3.3	TBD	ELM TANK CHANGEOUT	TBD	USED AS REACTANT IN MATERIALS PROCESSING. CORROSIVE. EXPLOSIVE WITH C12 AND S1H4.
56	JEM	EXPERIMENT FLUIDS	AMMONIA	TBD	TBD	1.1	TBD	ELM TANK CHANGEOUT	TBD	USED AS REACTANT FOR MATERIALS PROCESSING. TOXIC. CORROSIVE.
59	JEM	EXPERIMENT FLUIDS	C12	TBD	TBD	4.4	TBD	ELM TANK CHANGEOUT	TBD	USE AS REACTANT IN MATERIALS PROCESSING. CORROSIVE. TOXIC. EXPLOSIVE WITH PROPANE.
60	JEM	EXPERIMENT FLUIDS	S1H4 (SILANE)	TBD	TBD	3.3	TBD	ELM TANK CHANGEOUT	TBD	USED AS REACTANT FOR MATERIALS PROCESING. TOXIC AND CORROSIVE. ISOLATE FROM H2O.
65	JEM	LIFE SCIENCE FLUIDS	GN2	TBD	TBD	13.5	TBD	SS CORE	TBD	N2 IS MIXED WITH O2 FOR RESPIRATION. STABLE.
66	JEM	LIFE SCIENCE FLUIDS	GO2	TBD	TBD	51.7	TBD	SS CORE	TBD	USED FOR RESPIRATION. FLAMMABLE.
67	JEM	LIFE SCIENCE FLUIDS	CO2	TBD	TBD	11	TBD	ELM COMMON GAS SUPPLY	TBD	USED FOR RESPIRATION. CORROSIVE.
68	JEM	LIFE SCIENCE FLUIDS	H2O	TBD	TBD	83.6	TBD	JEM ELM SELF PROVISION	TBD	POTABLE WATER MAY BE BROUGHT OVER FROM CORE ECLSS.
61	JEM	SUBPRODUCT FLUIDS	NH4C1	NONE	SMALL	NONE	NONE	N/A	TBD	BY PRODUCT OF REACTION.
62	JEM	SUBPRODUCT FLUIDS	HC1	NONE	SMALL	NONE	NONE	N/A	TBD	BY PRODUCT FROM EXPERIMENT
63	JEM	SUBPRODUCT FLUIDS	CO2	NONE	SMALL	NONE	NONE	N/A	TBD	EXPERIMENT BY PRODUCT
64	JEM	SUBPRODUCT FLUIDS	H2O	NONE	SMALL	NONE	NONE	N/A	TBD	EXPERIMENT BYPRODUCT

Table 4.3-4 JEM Experiment Supply and Disposal Fluids Interface Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	INLET AND OUTLET FLUID CONDITIONS: FROM / TO	PRESSURE (PSIA)	TEMP. (F)	LINE SIZES (INCHES)	METHOD OF WASTE MANAGEMENT	FAILURE TOLERANCE	REMARKS
49	JEM	EXPERIMENT FLUIDS	AIR	ELM EXPERIMENTS	19 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
50	JEM	EXPERIMENT FLUIDS	Ar	ELM COMMON GAS SUPP. EXPERIMENT ATMOSPHER	19 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
51	JEM	EXPERIMENT FLUIDS	Kr	ELM COMMON GAS SUPP. EXPERIMENT	<19 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
52	JEM	EXPERIMENT FLUIDS	GHe	ELM COMMON GAS SUPP. EXPERIMENT	<19 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
53	JEM	EXPERIMENT FLUIDS	GH2	ELM INDIVIDUAL TANK EXPERIMENT	<19 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
54	JEM	EXPERIMENT FLUIDS	GO2	SS CORE EXPERIMENT	<19 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
55	JEM	EXPERIMENT FLUIDS	PROPANE	ELM INDIVIDUAL TANK EXPERIMENT	<19 TBD	TBD TBD	TBD TBD	VENT TO SPACE AFTER TREATING	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
56	JEM	EXPERIMENT FLUIDS	AMMONIA	ELM INDIVIDUAL TANK EXPERIMENT	<19 TBD	TBD TBD	TBD TBD	VENT TO SPACE AFTER TREATING	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
59	JEM	EXPERIMENT FLUIDS	Cl2	ELM INDIVIDUAL TANK EXPERIMENT	<19 TBD	TBD TBD	TBD TBD	VENT TO SPACE AFTER PROCSSING	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
60	JEM	EXPERIMENT FLUIDS	SiH4 (SILANE)	ELM INDIVIDUAL TANK EXPERIMENT	<19 TBD	TBD TBD	TBD TBD	VENT TO SPACE AFTER TREATING	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
65	JEM	LIFE SCIENCE FLUI	GN2	SS CORE LIFE EXPERIMENT	14.7 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
66	JEM	LIFE SCIENCE FLUI	GO2	SS CORE LIFE EXPERIMENT	14.7 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
67	JEM	LIFE SCIENCE FLUI	CO2	ELM COMMON SUPPLY LIFE EXPERIMENT	14.7 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
68	JEM	LIFE SCIENCE FLUI	H2O	ELM TANK CHANGEOUT LIFE EXPERIMENT	14.7-30 TBD	TBD TBD	TBD TBD	VENT TO SPACE	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
61	JEM	SUBPRODUCT FLUIDS	NH4Cl	EXPERIMENT DISPOSAL	TBD TBD	TBD TBD	TBD TBD	CAPTURE	TBD	MUST BE CAPTURED AND RETURNED TO EARTH ON SHUTTLE.
62	JEM	SUBPRODUCT FLUIDS	HCl	EXPERIMENT DISPOSAL	TBD TBD	TBD TBD	TBD TBD	VENT TO SPACE AFTER TREATING	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
63	JEM	SUBPRODUCT FLUIDS	CO2	EXPERIMENT DISPOSAL	TBD TBD	TBD TBD	TBD TBD	VENT TO SPACE AFTER TREATING	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.
64	JEM	SUBPRODUCT FLUIDS	H2O	EXPERIMENT DISPOSAL	TBD TBD	TBD TBD	TBD TBD	VENT TO SPACE AFTER TREATING	TBD	VENT TO SPACE MAY NOT BE ALLOWED. WASTE WOULD BE COLLECTED AND SENT TO INTEGRATED WASTE SYSTEM.

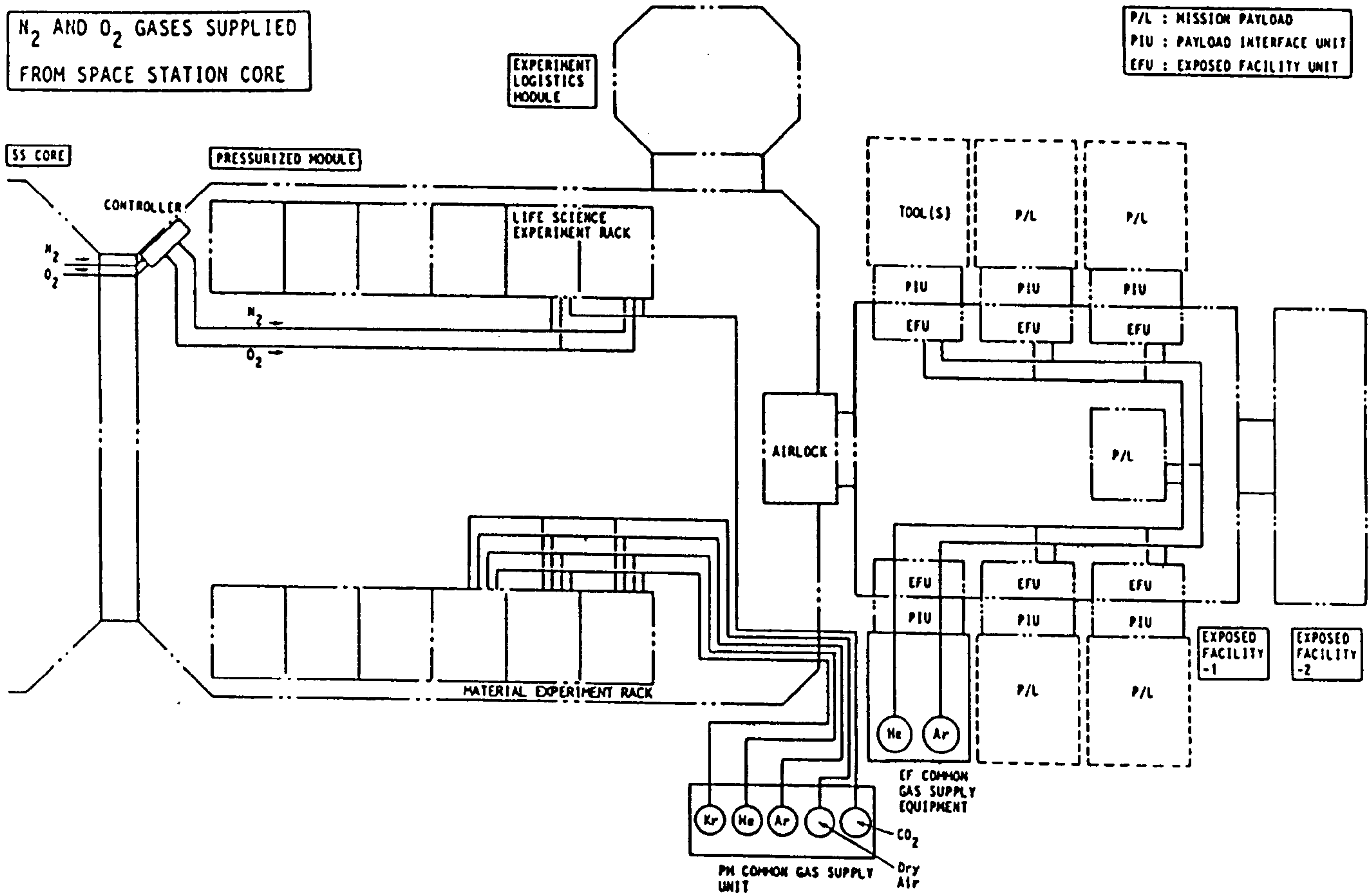

Figure 4.3-4 Vacuum and Gas Vent

The Space Station baseline IWFS will accept only specific gases for disposal. These gases are shown in Table 4.3-5 along with the quantities of each expected to be discarded by the JEM. The fluids that cannot be disposed of by IWFS will be stored in portable pressure vessels (PPVs) and returned to earth on the NSTS Shuttle. A compilation of all the fluids to be disposed of by the JEM is shown in Table 4.3-4.

The vacuum vent system will be is used for venting experiments at pressures from .25 torr on down. It will remove such a small quantity of fluids from the experiments that they will be vented directly to space. This provides a ready source of vacuum down to 1×10^{-3} torr. Higher quality vacuum will be obtained by augmenting the system with user provided pumps located in the racks where necessary.

c) Experiment Water Supply and Waste Water Management

The experiment Water Supply and Waste Water Management Experiment are shown in Figure 4.3-5. Experiment water will be supplied only to life sciences experiments in the JEM. The materials experiments will be required no water supply. The water requirement for the life sciences experiments is included in Table 4.3-2. An optional water supply line is shown in Figure 4.3-4. This would eliminate some or all of the need for experimental water supply from the ELM by using excess water from Space Station ECLSS and other sources in the core Space Station. This remains as merely an option. Disposal of experiment water after use in the life sciences experiments will be to contaminant waste cartridges. These PPVs will be returned to earth in the ELM on the space shuttle. There are no plans to process this waste or to integrate it with other Space Station systems.

Table 4.3-5 JEM Waste Fluids (lbm/year)

Fluid	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Argon	608	608	608	608	608	608	608	608	608	608
CO2	0	0	0	0	0	0	0	0	0	0
CO2/CH4	0	0	0	0	0	0	0	0	0	0
Freon	0	0	0	0	0	0	0	0	0	0
Helium	18	18	18	18	18	18	18	18	18	18
Hydrogen	1	1	1	1	1	1	1	1	1	1
Nitrogen	54	54	54	54	54	54	54	54	54	54
Oxygen	30	30	30	30	30	30	30	30	30	30
Xenon	0	0	0	0	0	0	0	0	0	0
Krypton	40	40	40	40	40	40	40	40	40	40
Totals:	751	751	751	751	751	751	751	751	751	751

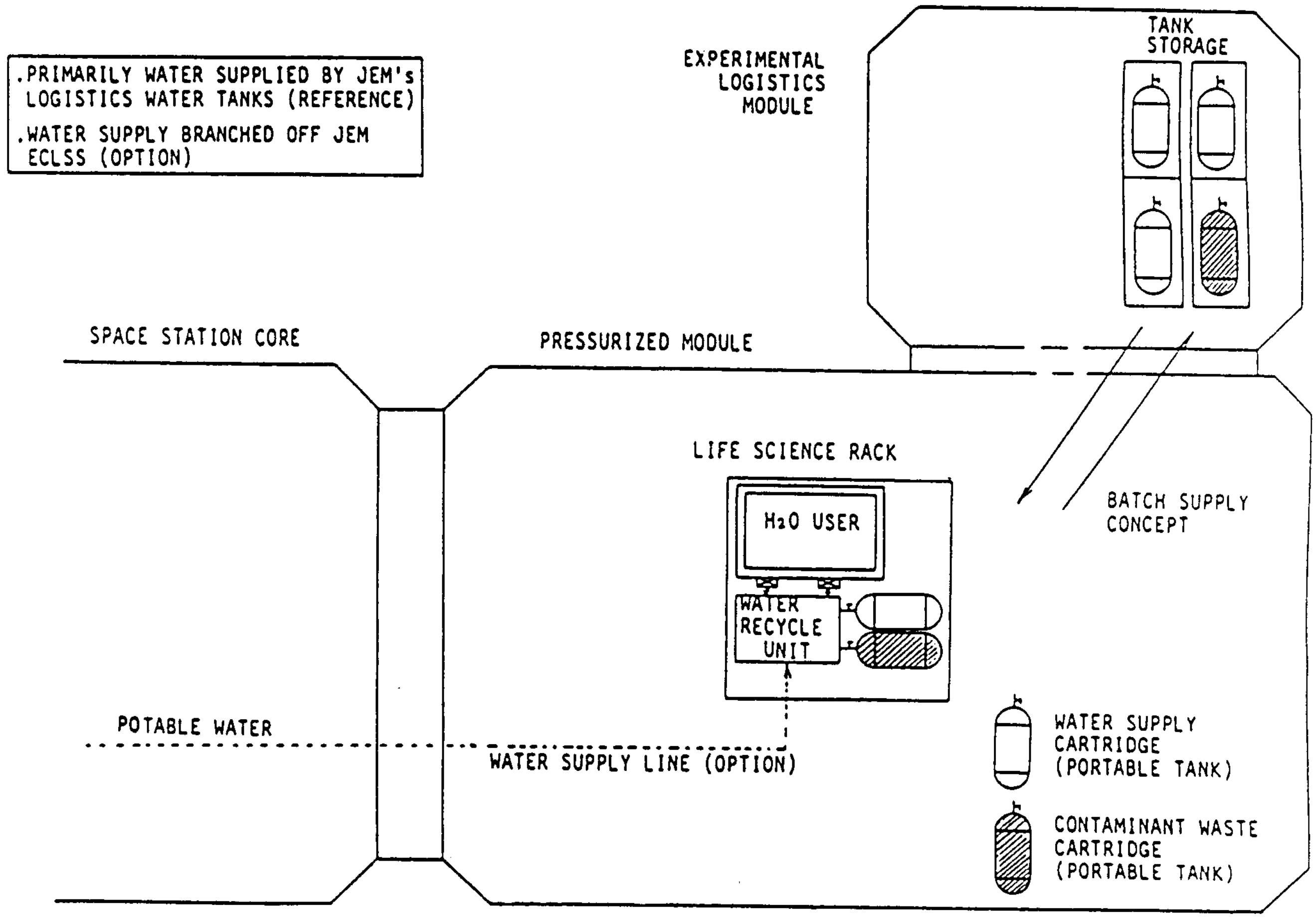

Figure 4.3-5 Experiment Water Supply and Waste Water Management

4.4 JAPANESE EXPERIMENTAL MODULE REFERENCES

1) Fluids Technical Integration Panel, presented at Marshall Space Flight Center, Huntsville, AL, October, 1986.

2) Peterson, T., Space Station Fluid Inventories of the Integrated Waste Fluid and Integrated Water Systems, PIR No. 191. NASA Lewis Research Center, Cleveland, OH, March, 1987.

5.0 COLUMBUS MODULE

The Columbus module will be a laboratory module outfitted for both materials processing and life sciences experiments. The Columbus module will be built and funded by the European Space Agency (ESA) providing the Europeans the opportunity to perform their own experiments without building their own space station.

At present, almost no information is available about the requirements, descriptions, and configurations of the Columbus module. However, Mr. Hans D. Schmitz, in the European Space Agency, has offered his assistance in providing data associated with the Columbus Module. As data becomes available, it will be added to the database and used to update the commonality study.

5.1 COLUMBUS MODULE OVERALL REQUIREMENTS

The fixed, overall requirements for Columbus are unavailable. Requirements that can be derived for Columbus are presented in Table 5.1-1.

Table 5.1-1 Columbus Derived Requirements

- Provide an environment which allows crew members to perform a selected group of experiments within a "shirt sleeve" environment.
- Provide a process fluids system.
- Provide a waste management system.
- Provide a vacuum vent system.

5.2 COLUMBUS MODULE FLUID SYSTEMS REQUIREMENTS

Columbus Fluids Subsystem requirements are TBD.

5.3 COLUMBUS MODULE FLUID SYSTEMS DESCRIPTIONS AND CONFIGURATIONS

5.3.1 Environmental Control and Life Support (ECLSS)

The Columbus Module ECLSS configuration is TBD.

5.3.2. Process Fluids Supply System

The Columbus Module Process Fluids Supply System configuration is TBD. The quantities of fluids to be resupplied are also unavailable, but can be derived for some fluids based on waste quantities established for the Japanese Experimental Module and the United States Laboratory. These quantities are shown in Table 5.3-1.

5.3.3. Waste Fluids System

The Columbus Module Waste Fluids System configuration is TBD. The quantities of fluids available for disposal to the Space Station Integrated Waste Fluids System are shown in Table 5.3-1.

Table 5.3-1 Columbus Module Waste Fluids (lbm/year)

Fluid	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Argon	167	167	167	167	167	167	167	167	167	167
CO2 **	104	104	104	104	104	104	104	104	104	104
CO2/CH4	0	0	0	0	0	0	0	0	0	0
Freon	3	3	3	3	3	3	3	3	3	3
Helium	9	9	9	9	9	9	9	9	9	9
Hydrogen	1	1	1	1	1	1	1	1	1	1
Nitrogen	54	54	54	54	54	54	54	54	54	54
Oxygen	30	30	30	30	30	30	30	30	30	30
Xenon	44	44	44	44	44	44	44	44	44	44
Krypton	40	40	40	40	40	40	40	40	40	40
Totals	452	452	452	452	452	452	452	452	452	452

* Waste gas amounts not specified by ESA; assumed quantities are the smaller amounts of USL and JEM quantities

** CO2 amounts assumed the same as USL; ESA has specified Columbus as having biological experiment activities

5.4 COLUMBUS MODULE REFERENCES

Peterson, T., Space Station Fluid Inventories of the Integrated Waste Fluids and Integrated Water Systems, PIR No. 191. NASA Lewis Research Center, Cleveland, OH, March, 1987.

6.0 INTEGRATED WASTE FLUID SYSTEM (IWFS)

6.1 INTEGRATED WASTE FLUID SYSTEM OVERALL REQUIREMENTS

The overall requirements for the IWFS are presented in Table 6.1-1.

Table 6.1-1 Overall Requirements for the Integrated Waste Fluid System

1) Collect waste fluids discarded by the station elements that are compatible with safe collection and storage.

2) Transfer, condition and allocate the collected fluids for disposal or return systems.

3) Control and monitor collection, transfer, storage, conditioning, allocation and disposal of waste fluids.

4) Will not preclude the ability of individual station elements to provide a vacuum resource to the user interface.

5) Waste fluids that cannot be accepted by the IWFS must be disposed of by the Space Station Program Element (SSPE) or system associated with or operating from a SSPE, provided that the requirements of waste handling and venting are met.

6.2 INTEGRATED WASTE FLUID SYSTEM REQUIREMENTS

Integrated fluid system requirements are presented in Table 6.2-1.

Table 6.2-1 Integrated Fluid System Requirements

Parameter	Requirements
Growth	1) IOC systems shall have growth and on-orbit reconfiguration capability to accommodate changing demands in user fluid quantities. 2) System shall incorporate scarring to accommodate additional integrated system at logical full operational capability.
Integrated Design	1) System shall be integrated to minimize fluid management hardware development and operational cost.
Interface Hardware	1) Fluid interface components shall be standarized, and fluid transfer interface hardware shall be designed to preclude mating to the wrong connector.
Fluid Storage Requirements	1) A fluid quantity measurement capability shall be provided in both the storage and resupply systems. 2) Leakage detection, isolation, and control shall be provided and shall comply with station environmental and contamination requirements.

Table 6.2-1 Integrated Fluid System Requirements (Continued)

Acceleration and Orientation Constraints	1)	The resupply/transfer of fluids shall be independent of the gravitational environment and/or specific orientation of any interfacing element.
Waste Fluid Handling	1)	No overboard dumping of solids or liquids.
	2)	No particles released from vents shall exceed TBD micron in diameter.
	3)	The integrated overboard venting of gases, at any time, shall comply with the external contamination requirements.
	4)	Accumulative venting or dumping from all SSPE's shall be inventoried to support the integrated contamination control analysis.
	5)	A system will be provided to manage potential venting and dumping from all SSPE's and systems associated with or operating from an SSPE.
	6)	Design will comply with contamination and micro-gravity requirements. Controllable to permit scheduling of the dumps with minimum impacts to observer and microgravity activity scheduling. Minimize the frequency and duration of nonoperational dumps.

6.3 INTEGRATED WASTE FLUID SYSTEM DESCRIPTION AND CONFIGURATION

Possible waste fluid sources on the IOC Space Station include the four core Modules (United States Laboratory (USL), Habitation, Japanese Experiment (JEM), and Columbus), the integrated nitrogen and water systems, attached payloads, environmental control and life support system (ECLSS), airlocks and in future, the fluids servicing facility. Fluid interfaces between these systems and the IWFS are presented in Figure 6.3-1. At this time, only the ECLSS, USL, attached payloads and JEM have identified quantifiable waste gas data. Columbus Module waste gas quantities may be derived from waste quantities generated for the JEM and the USL.. Waste fluid quantities generated from the remaining sources are either minimal or cannot be estimated at this time. Therefore, the fluid inventory data includes only the five Space Station elements previously mentioned.

Collection of Waste Fluids

Multiple deployable waste gas collection lines were recommended to capture and route all waste gases from Station elements to a central storage facility. Fluid waste system segregation was not recommended because of the wide variety of single and mixed type waste quantities expelled from the experiment labs, the relatively small amount of fluids, the presence of unwanted mixtures such as CO2 and methane produced in the Sabatier ECLSS and the time availability of attached payload waste gases.

Therefore, separate lines will be used to transfer reducing gases (hydrogen and methane) and oxidizing gases (oxygen) from each gas source to separate storage tanks in the central waste gas storage facility. Inert gases will be collected in either line depending on storage availability and the need to dilute either oxidizers or reducers at the central storage facility.

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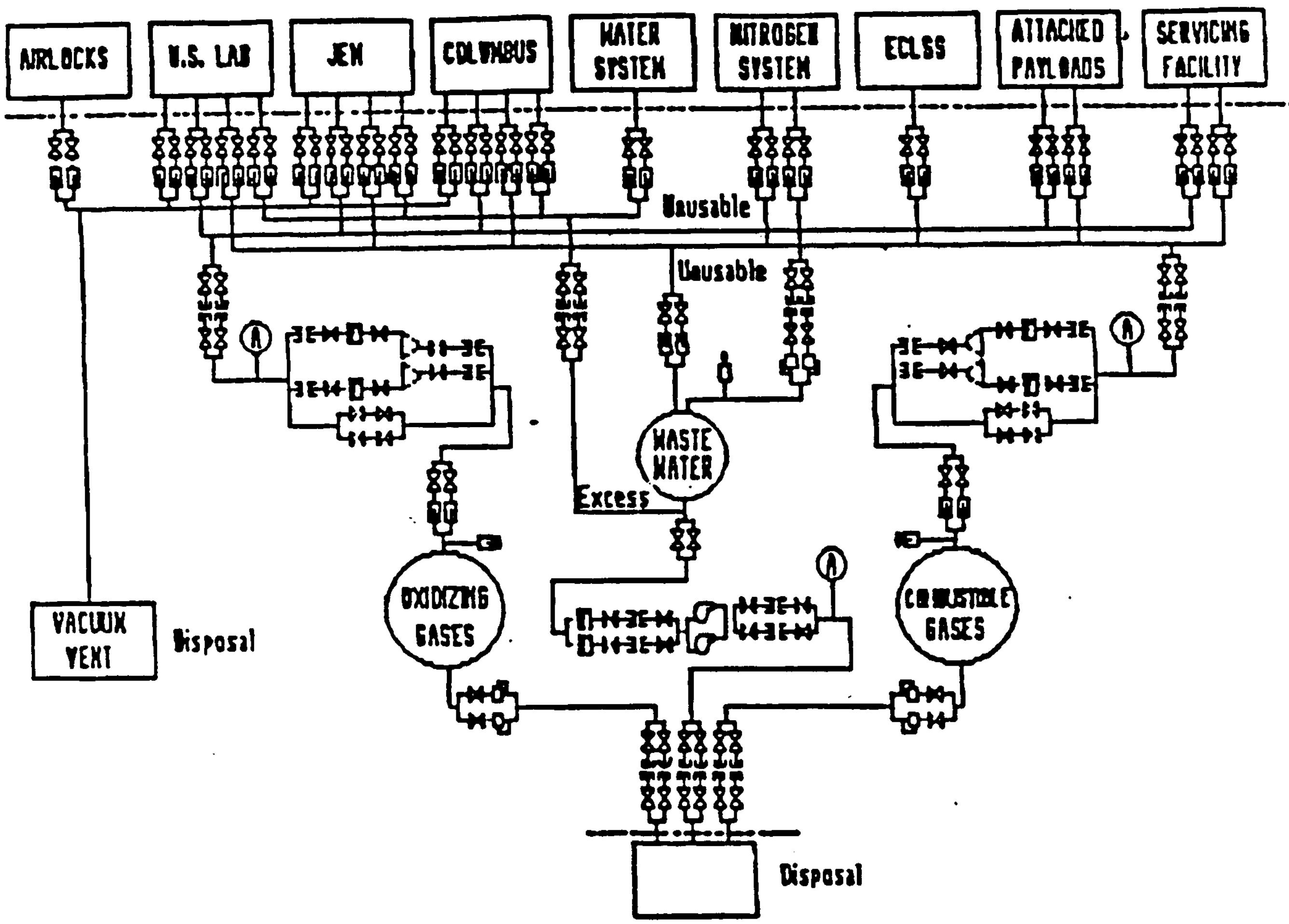

Figure 6.3-1 Integrated Waste Fluid System

Waste fluid collection will operate from 10 to 15 psia. Two low pressure compressors will be activated when the collection system reaches 15 psia which transfers fluids into a 35 psia accumulator. Fluid system requirements for the IWFS collection system are presented in Tables 6.3-1 and 6.3-2. The waste gases presented in Tables 6.3-1 and 6.3-2 represent only those gases suitable for IWFS storage and resistojet propulsion system use. Solvents, acids, oils and brine-type fluid mixtures will not be allowed to enter the IWFS.

Table 6.3-1 Integrated Waste Fluid System Fluid Inventory Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS) MEAN	RESUPPLY QUANTITY (LB/90 DAYS) MAX	RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
57	IWFS	ATT. PAYLOADS	Ar	80.5	TBD	TBD	TBD	FLUID TRANSFER FROM ATT. P/L	TBD	PRESENTLY NO REQUIREMENT TO INTEGRATE ATTACHED PAYLOADS FLUIDS WITH SPACE STATION.
58	IWFS	ATT. PAYLOADS	CO2	80.9	TBD	TBD	TBD	FLUID TRANSFER FROM ATT. P/L	TBD	PRESENTLY NO REQUIREMENT TO INTEGRATE ATTACHED PAYLOADS FLUIDS WITH SPACE STATION.
95	IWFS	ATT. PAYLOADS	GHe	180.4	TBD	TBD	TBD	FLUID TRANSFER FROM ATT. P/L	TBD	PRESENTLY NO REQUIREMENT TO INTEGRATE ATTACHED PAYLOADS FLUIDS WITH SPACE STATION.
99	IWFS	ATT. PAYLOADS	GH2	54.3	TBD	TBD	TBD	FLUID TRANSFER FROM ATT. P/L	TBD	PRESENTLY NO REQUIREMENT TO INTEGRATE ATTACHED PAYLOADS FLUIDS WITH SPACE STATION.
118	IWFS	ATT. PAYLOADS	GN2	79.6	TBD	TBD	TBD	FLUID TRANSFER FROM ATT. P/L	TBD	PRESENTLY NO REQUIREMENT TO INTEGRATE ATTACHED PAYLOADS FLUIDS WITH SPACE STATION.
114	IWFS	COL	Ar	TBD	TBD	41.75	41.75	FLUID TRANSFER FROM COLUMBUS	TBD	
115	IWFS	COL	CO2	TBD	TBD	26	26	FLUID TRANSFER FROM COLUMBUS	TBD	
116	IWFS	COL	FREON	TBD	TBD	0.75	0.75	FLUID TRANSFER FROM COLUMBUS	TBD	
117	IWFS	COL	GHe	TBD	TBD	2.25	2.25	FLUID TRANSFER FROM COLUMBUS	TBD	
119	IWFS	COL	TOTAL INERTS	TBD	TBD	105.25	105.25	FLUID TRANSFER FROM COLUMBUS	TBD	
120	IWFS	COL	GO2	TBD	TBD	7.5	7.5	FLUID TRANSFER FROM COLUMBUS	TBD	
121	IWFS	COL	GH2	TBD	.051 NOM	.25	.25	FLUID TRANSFER FROM COLUMBUS	TBD	
122	IWFS	ECLSS, BOSCH	GH2	TBD	.018 NOM	35	70	FLUID TRANSFER FROM ECLSS	TBD	
123	IWFS	ECLSS, SABATIER	CO2/CH4	TBD	.443 NOM	935	1870	FLUID TRANSFER FROM ECLSS	TBD	
125	IWFS	IWS	GN2	TBD	TBD	27	27	FLUID TRANSFER FROM IWS	TBD	
105	IWFS	JEM	Ar	TBD	TBD	152	152	FLUID TRANSFER FROM JEM	TBD	
106	IWFS	JEM	GHe	TBD	TBD	4.5	4.5	FLUID TRANSFER FROM JEM	TBD	
107	IWFS	JEM	FREON	TBD	TBD	0.75	0.75	FLUID TRANSFER FROM JEM	TBD	
108	IWFS	JEM	GN2	TBD	TBD	13.5	13.5	FLUID TRANSFER FROM JEM	TBD	
109	IWFS	JEM	Xe	TBD	TBD	11	11	FLUID TRANSFER FROM JEM	TBD	
110	IWFS	JEM	Kr	TBD	TBD	10	10	FLUID TRANSFER FROM JEM	TBD	
111	IWFS	JEM	TOTAL INERTS	TBD	.082 NOM	194	194	FLUID TRANSFER FROM JEM	TBD	
112	IWFS	JEM	GO2	TBD	.003 NOM	7.5	7.5	FLUID TRANSFER FROM JEM	TBD	

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Table 6.3-1 (Continued) Integrated Waste Fluid System Fluid Inventory Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS)		RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
						MEAN	MAX			
113	IWFS	JEM	GH2	TBD	.001 NOM	0.25	0.25	FLUID TRANSFER FROM JEM	TBD	
96	IWFS	USL	Ar	TBD	TBD	41.75	83.5	FLUID TRANSFER FROM USL	TBD	
97	IWFS	USL	CO2	TBD	TBD	26	52	FLUID TRANSFER FROM USL	TBD	
98	IWFS	USL	FREON	TBD	TBD	.75	1.5	FLUID TRANSFER FROM USL	TBD	
100	IWFS	USL	GN2	TBD	TBD	328.75	657.5	FLUID TRANSFER FROM USL	TBD	
101	IWFS	USL	Xe	TBD	TBD	11	22	FLUID TRANSFER FROM USL	TBD	
102	IWFS	USL	TOTAL INERTS	TBD	.375 NOM	410.5	821	FLUID TRANSFER FROM USL	TBD	
103	IWFS	USL	GO2	TBD	.042 NOM	45.75	91.5	FLUID TRANSFER FROM USL	TBD	
104	IWFS	USL	GH2	TBD	.001 NOM	.75	1.5	FLUID TRANSFER FROM USL	TBD	

Table 6.3-2 Integrated Waste Fluid System Fluid Interface Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	INLET AND OUTLET FLUID CONDITIONS				METHOD OF WASTE MANAGEMENT	FAILURE TOLERANCE	REMARKS
				FROM TO	PRESSURE (PSIA)	TEMP. (F)	LINE SIZES (INCHES)			
135	IWFS	ATT PAYLOADS	INERTS	ATT PAYLOADS IWFS STORAGE	15 300	70 70	.375 .5/.25	RESISTOJETS	SINGLE	
136	IWFS	ATT PAYLOADS	OXIDIZERS	ATT PAYLOADS IWFS STORAGE	15 TBD	70 TBD	TBD TBD	RESISTOJETS	SINGLE	
137	IWFS	ATT PAYLOADS	REDUCERS	ATT PAYLOADS IWFS STORAGE	15 300	70 70	.25 .25	RESISTOJETS	SINGLE	
132	IWFS	COL	INERTS	COL IWFS STORAGE	15 300	70 70	.375 .5/.25	RESISTOJETS	SINGLE	
133	IWFS	COL	OXIDIZERS	COL IWFS STORAGE	15 300	70 70	.375 .5	RESISTOJETS	SINGLE	
134	IWFS	COL	REDUCERS	COL IWFS STORAGE	15 300	70 70	.25 .25	RESISTOJETS	SINGLE	
138	IWFS	ECLSS	INERTS	ECLSS, BOSCH IWFS STORAGE	30 300	70 70	.375 .5/.25	RESISTOJETS	SINGLE	
139	IWFS	ECLSS	REDUCERS	ECLSS, BOSCH IWFS STORAGE	100 300	90 70	.375 .25	RESISTOJETS	SINGLE	
140	IWFS	ECLSS	REDUCERS	ECLSS, SABATIER IWFS STORAGE	15 300	70 70	.375 .25	RESISTOJETS	SINGLE	
129	IWFS	JEM	INERTS	JEM IWFS STORAGE	15 300	70 70	.375 .5/.25	RESISTOJETS	SINGLE	
130	IWFS	JEM	OXIDIZERS	JEM IWFS STORAGE	15 300	70 70	.375 .5	RESISTOJETS	SINGLE	
131	IWFS	JEM	REDUCERS	JEM IWFS STORAGE	15 300	70 70	.25 .25	RESISTOJETS	SINGLE	
126	IWFS	USL	INERTS	USL IWFS STORAGE	15 300	70 70	.375 .5/.25	RESISTOJETS	SINGLE	
127	IWFS	USL	OXIDIZERS	USL IWFS STORAGE	15.0 300	70 70	.375 .5	RESISTOJETS	SINGLE	
128	IWFS	USL	REDUCERS	USL IWFS STORAGE	15 300	70 70	.25 .25	RESISTOJETS	SINGLE	

Storage

The IWFS storage subsystem will provide separate tanks for oxidizing/inert gas mixtures, reducing/inert gas mixtures and excess water. Previous studies have assumed that the storage subsystem will be mounted near the core module area on the transverse boom structure. To meet long duration hold times imposed by external environment criteria, the storage facility must accommodate a 15 day hold time allowing propulsive venting to be delayed until quiescent station operation.

Dual string compressors are used to raise the gases stored in the accumulators at 35 psia to a 300 psia storage tank pressure. The storage pressure of 300 psia was chosen based on the compressor technology developed for the Manned Orbiting Research Laboratory (MORL). A component list, including both collection and storage subsystems of the IWFS is presented in Table 6.3-3.

6.4 INTEGRATED WASTE FLUID SYSTEM REFERENCES

1) Peterson, T., Space Station Fluid Inventories of the Integrated Waste Fluid and Integrated Water Systems, PIR No. 159. NASA Lewis Research Center, Cleveland, OH, March 25, 1987.

2) Fluids Technical Integration Panel Data. Presented at Marshall Space Flight Center, Huntsville, AL, October 1986.

3) Data provided by John Griffin at Johnson Space Center, April 1987.

Table 6.3-3 Integrated Waste Fluid System Component List

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ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
191	IWFS,	REGULATOR,	6	TBD	TBD	GN2	2.2	TBD	TBD
192	IWFS,	SENSOR, PRESSURE	42	TBD	300	RE/OX/INERTS	0.6	TBD	TBD
193	IWFS,	SENSOR, PRESSURE	14	TBD	30	H2O	0.1	TBD	TBD
194	IWFS,	FILTER, INLINE	4	.5	300	ALL	0.5	TBD	TBD
195	IWFS,	DISCONNECT,	16	.375	15	OXIDIZERS	0.5	TBD	TBD
201	IWFS,	PRESSURE VESSEL,	2	.5	300	OXIDIZERS	101.8	TBD	TBD
202	IWFS,	PRESSURE VESSEL,	4	.25	300	REDUCERS	101.8	TBD	TBD
203	IWFS,	PRESSURE VESSEL,	1	.25	30	H2O	42.0	TBD	TBD
204	IWFS,	PRESSURE VESSEL, ACCUMULATORS	2	.25/.5	35	REDUCERS	8.3	TBD	TBD
205	IWFS,	PRESSURE VESSEL, ACCUMULATORS	1	.25	TBD	H2O	3.2	TBD	TBD
206	IWFS,	MISC, COMPRESSOR	2	.5	300	OXIDIZERS	30.0	TBD	TBD
207	IWFS,	MISC, COMPRESSOR	2	.25	300	REDUCERS	30.0	TBD	TBD
208	IWFS,	MISC, PUMP	2	TBD	TBD	H2O	35.0	TBD	TBD
190	IWFS,	REGULATOR,	2	TBD	300	OXIDIZERS	5.0	TBD	TBD
56	IWFS,	PRESSURE VESSEL, ACCUMULATORS	2	.25/.5	35	OXIDIZERS	8.3	TBD	TBD
175	IWFS,	VALVE, ELECTRIC	34	.375	15	OXIDIZERS	1.5	TBD	TBD
176	IWFS,	VALVE, ELECTRIC	40	.25	15.0	REDUCERS	1.5	TBD	TBD
177	IWFS,	VALVE, ELECTRIC	2	.25	180	REDUCERS	1.5	TBD	TBD
178	IWFS,	VALVE, ELECTRIC	6	.25	30	GN2	2.2	TBD	TBD
179	IWFS,	VALVE, ELECTRIC	2	.25	800	GH2	1.5	TBD	TBD
180	IWFS,	VALVE, ELECTRIC	24	.25	30	H2O	3.0	TBD	TBD
181	IWFS,	VALVE, ELECTRIC	8	.5	15	ALL	1.5	TBD	TBD
182	IWFS,	VALVE, RELIEF	2	.5	300	OXIDIZERS	2.0	TBD	TBD
183	IWFS,	VALVE, RELIEF	8	.25	300	REDUCERS	2.0	TBD	TBD
185	IWFS,	VALVE, RELIEF	1	.25	30	H2O	3.5	TBD	TBD
186	IWFS,	VALVE, CHECK	12	.5	300	OXIDIZERS	1.0	TBD	TBD
187	IWFS,	VALVE, CHECK	14	.25	300	REDUCERS	1.0	TBD	TBD
188	IWFS,	VALVE, CHECK	8	.25	30	H2O	1.5	TBD	TBD
189	IWFS,	REGULATOR,	2	TBD	300	REDUCERS	5.0	TBD	TBD
198	IWFS,ATT PAYLOADS	DISCONNECT,	2	.25	800	REDUCERS	1.0	TBD	TBD
197	IWFS,ECLSS	DISCONNECT,	2	.25	180	REDUCERS	0.7	TBD	TBD
200	IWFS,INS	DISCONNECT,	4	.25	750	GN2	1.0	TBD	TBD
199	IWFS,IWS	DISCONNECT,	16	.25	30	H2O	0.7	TBD	TBD
196	IWFS,LABS	DISCONNECT,	12	.25	15	REDUCERS	0.5	TBD	TBD

7.0 INTEGRATED WATER SYSTEM (IWS)

7.1 INTEGRATED WATER SYSTEM OVERALL REQUIREMENTS

The integrated water system will be responsible for providing water to the U.S. Laboratory, Japanese Experimental Module, Columbus Module and propulsion system. The system will be capable of accepting excess potable water from the Environmental Control and Life Support System (ECLSS) and the Orbiter and will also be capable of transferring excess water to the IWFS.

7.2 INTEGRATED WATER SYSTEM REQUIREMENTS

Integrated water system requirements are presented in Table 7.2-1.

Table 7.2-1 Integrated Water System Requirments

Parameter		Requirements
Growth	1)	IOC systems shall have growth and on-orbit reconfiguration capability to accommodate changing demands in user fluid quantities.
	2)	System shall incorporate scarring to accommodate additional integrated system at logical full operational capability.
Integrated Design	1)	System shall be integrated to minimize fluid management hardware development and operational cost.
Interface Hardware	1)	Fluid interface components shall be standardized and fluid transfer interface hardware shall be designed to preclude mating to the wrong connector.
Fluid Storage Requirements	a)	A fluid quantity measurement capability shall be provided in both the storage and resupply systems.
	2)	Leak detection, isolation, and control shall be provided and shall comply with station environmental and contamination requirements.
	3)	No liquids will be vented overboard.

7.3 INTEGRATED WATER SYSTEM DESCRIPTION AND CONFIGURATION

A schematic of the IWS is presented in Figure 7.3-1. The IWS will capture all water available from the NSTS Orbiter, the ECLSS and, if necessary, water resupplied from the Logistics module to meet water resupply requirements. The system will consist of a collection subsystem, a storage subsystem, and a distribution subsystem to supply all station users including the United States Laboratory, Japanese Experimental Module, Columbus, Propulsion, and the Integrated Waste Fluid System. The bladder type water storage tanks of the IWS will be pressurized by nitrogen from the integrated nitrogen system. When the water tanks are resupplied, excess nitrogen pressurant will be channeled to the integrated waste fluid system for propulsive disposal. An alternate solution to disposing the water would be to channel it through the electrolysis unit for a more efficient means of propulsive disposal through the oxygen/hydrogen thrusters.

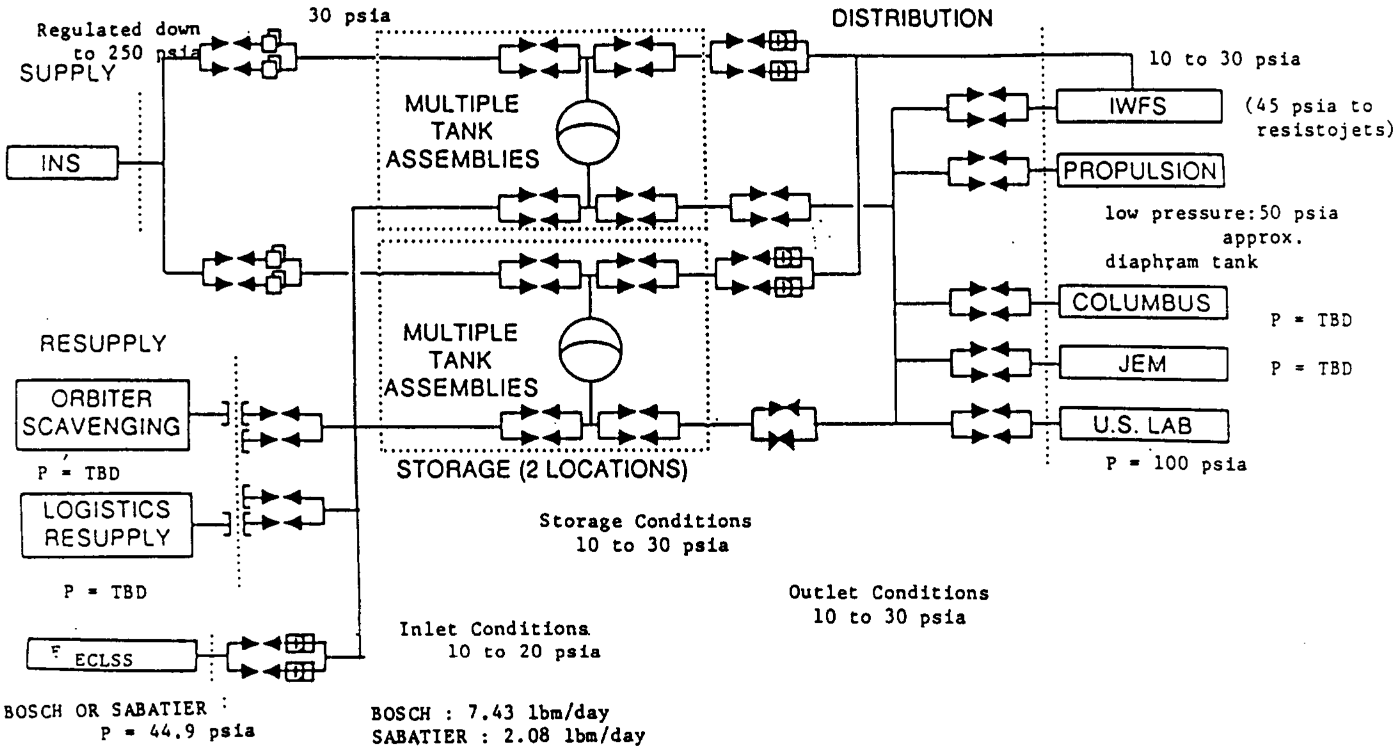

Figure 7.3-1 Schematic of the Integrated Water System

Parameters that affect the water balance of the integration system are listed in Table 7.3-1.

Table 7.3-1 Variables that Affect Space Station Water Balance and the Baseline Configuration

Parameters	Baseline Configuration
CO_2 Reduction Process in ECLSS	Bosch
Station Crew Size	8
EVA's per 90 days	39
EVA duration	6
EMU Loop Closure	Closed
Food Water Content (lbm/man/day)	1.1
Orbiter Crew Size	8
Orbiter Crew on Station	4
Orbiter Power Level (kW)	10.0
Orbiter Stay Duration (days)	5
Orbiter Visits per 90 Days	2
Percentage of Water Recovery from Laboratory Experiments	85%

The configuration baselined for this study will be the BOSCH CO_2 reduction process in the environmental control and life support system. This system will be capable of generating excess potable water at a rate of 7.43 lbm each day. This prediction is based on an eight person crew with 1.1 lbm of water in the food per man day. Alternatively, if the Sabatier CO_2 reduction process was used only 2.08 lbm of excess potable per day would be generated.

Shuttle operations that have a major effect on the water balance include mission duration, power availability to the fuel cells while the shuttle is docked to the station, and the number of shuttle flights per year.

A NASA study indicated that excess potable water generated from the Orbiter may range from 342 lbm/visit (with the Space Station to orbiter 10 kW power cord for a five day mission) up to 2538 lbm/visit (without the 10 kW power cord for an eight day visit).

The NSTS orbiter also generates hygiene water which accumulates in the orbiter waste tanks during ascent to docking with the Station. This quantity of 254 lbm per visit is independent of mission duration and power cord use. Available potable and hygiene quantities generated under various operations are summarized in Table 7.3-2. The current shuttle operation scenario is a five day orbiter mission with a 10 kW station to orbiter power cord, and eight flights per year.

The present fluids inventory for the integrated water system is presented in Tables 7.3-3 and 7.3-4, and a component list is presented in Table 7.3-5. As water requirements become more apparent, fluid inventories will be revised to implement changes in the water balance and the integrated configuration.

Table 7.3-2 Excess Water Generated from the Orbiter

Option	Potable Water Generated Per Flight (lbm/flight)	Hygiene Water Generated Per Flight (lbm/flight)
1) 5 Day Mission 10 kW Power Cord	342	254
2) 5 Day Mission No Power Cord	1860	254
3) 8 Day Mission 10 kW Power Cord	2040	254
4) 8 Day Mission No Power Cord	2538	254

7.4 INTEGRATED WATER SYSTEM REFERENCES

1) Peterson, T., Space Station Fluid Inventories of the Integrated Waste Fluid and Integrated Water Systems, PIR No. 159. NASA Lewis Research Center, Cleveland, OH, March 25, 1987.

2) Fluids Technical Integration Panel Data. Presented at Marshall Space Flight Center, Huntsville, AL, October 1986.

3) Data provided by John Griffin at Johnson Space Center, April 1987.

Table 7.3-3 Integrated Water System Fluid Inventory Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS)		RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
						MEAN	MAX			
86	IWS	STORAGE	H2O	608	TBD TBD	TBD	TBD	FROM ORBITER AND EXCESS ECLSS	POTABLE	WATER ACCUMULATEION FROM LOG MODULE, ORBITER, AND ECLSS.
94	IWS	STORAGE	GN2	27	TBD TBD	TBD	TBD	FLUID TRANSFER FROM INS	TBD	

Table 7.3-4 Integrated Water System Fluid Interface Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	INLET AND OUTLET FLUID CONDITIONS				METHOD OF WASTE MANAGEMENT	FAILURE TOLERANCE	REMARKS
				FROM TO	PRESSURE (PSIA)	TEMP. (F)	LINE SIZES (INCHES)			
89	IWS	DISTRIBUTION	H2O	IWS USL	10 TO 30 10 TO 30	70 70	TBD TBD	FILTER	SINGLE	
90	IWS	DISTRIBUTION	H2O	IWS COLUMBUS	10 TO 30 10 TO 30	70 70	TBD TBD	FILTER	SINGLE	
91	IWS	DISTRIBUTION	H2O	IWS JEM	10 TO 30 10 TO 30	70 70	TBD TBD	FILTER	SINGLE	
92	IWS	DISTRIBUTION	H2O	IWS PROPULSION	10 TO 30 10 TO 30	70 70	TBD TBD	FILTER	SINGLE	
93	IWS	DISTRIBUTION	H2O	IWS IWFS	10 TO 30 10 TO 30	70 70	TBD TBD	FILTER	SINGLE	
87	IWS	STORAGE	H2O	LOG MODULE IWS	10 TO 20 10 TO 30	70 70	TBD TBD	RESISTOJET	SINGLE	
88	IWS	STORAGE	H2O	ECLSS IWS	10 TO 20 10 TO 30	70 70	TBD TBD	RESISTOJET	SINGLE	

Table 7.3-5 Integrated Water System Component List

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ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
217	IWS,	DISCONNECT,	4	TBD	30	H2O	7.0	TBD	TBD
215	IWS,	FILTERS, INLINE	TBD	TBD	30	H2O	1.0	TBD	TBD
216	IWS,	MISC, HEATER	305	N/A	N/A	H2O	0.5	TBD	TBD
218	IWS,	PRESSURE VESSEL,	8	TBD	30	H2O	76.0	TBD	TBD
212	IWS,	REGULATOR,	4	TBD	30	H2O	10.0	TBD	TBD
213	IWS,	SENSOR, PRESSURE	28	TBD	30	H2O	0.6	TBD	TBD
214	IWS,	SENSOR, TEMPERATURE	28	TBD	30	H2O	0.1	TBD	TBD
211	IWS,	VALVE, CHECK	6	TBD	30	H2O	1.5	TBD	TBD
210	IWS,	VALVE, RELIEF	8	TBD	30	H2O	3.5	TBD	TBD
209	IWS,	VALVE, SOLENOID, LATCHING	88	TBD	30	H2O	3.0	TBD	TBD

8.0 INTEGRATED NITROGEN SYSTEM (INS)

8.1 INTEGRATED NITROGEN SYSTEM OVERALL REQUIREMENTS

At IOC, the INS will provide nitrogen to the Environmental Control and Life Support System (ECLSS), Integrated Waste Fluid System (IWFS), Integrated Water System (IWS), U.S. Laboratory (USL), Columbus, and the Japanese Experimental Module (JEM). The INS will be scarred at IOC for high pressure requirements relative to Extravehicular Activity (EVA) Systems such as the Extravehicular Excursion Unit (EEU) and the Enhanced Mobility Unit (EMU) with additional high pressure requirements for the Orbital Maneuvering Vehicle (OMV) and the Servicing Facility. The Servicing Facility will also require scarring of the INS for a low pressure port for post IOC.

8.2 INTEGRATED NITROGEN SYSTEM REQUIREMENTS

Fluid system requirements for the integrated nitrogen system are presented in Table 8.2-1.

Table 8.2-1 Integrated Nitrogen System Fluid System Requirements

Parameter		Requirements
Growth	1)	IOC systems shall have growth and on-orbit reconfiguration capability to accommodate changing demands in user fluid quantities.
	2)	System shall incorporate scarring to accommodate additional integrated system at logical full operational capability.
Integrated Design	1)	System shall be integrated to minimize fluid management hardware development and operational cost.
Interface Hardware	1)	Fluid interface components shall be standardized and fluid transfer interface hardware shall be designed to preclude mating to the wrong connector.
Fluid Storage	1)	A gas quantity measurement capability shall be provided in both the storage and resupply subsystems.

8.3 INTEGRATED NITROGEN SYSTEM DESCRIPTION AND CONFIGURATION

The INS will consist of a resupply subsystem, emergency storage subsystem, and a distribution subsystem, and will include all hardware and software required to provide the functions of resupply, transfer, storage, conditioning, distribution, as well as control and monitoring of the nitrogen within the INS. A functional diagram is shown as Figure 8.3-1. The INS fluid resupply requirements are shown in Table 8.3-1 and the INS fluid interface requirements are shown in Table 8.3-2.

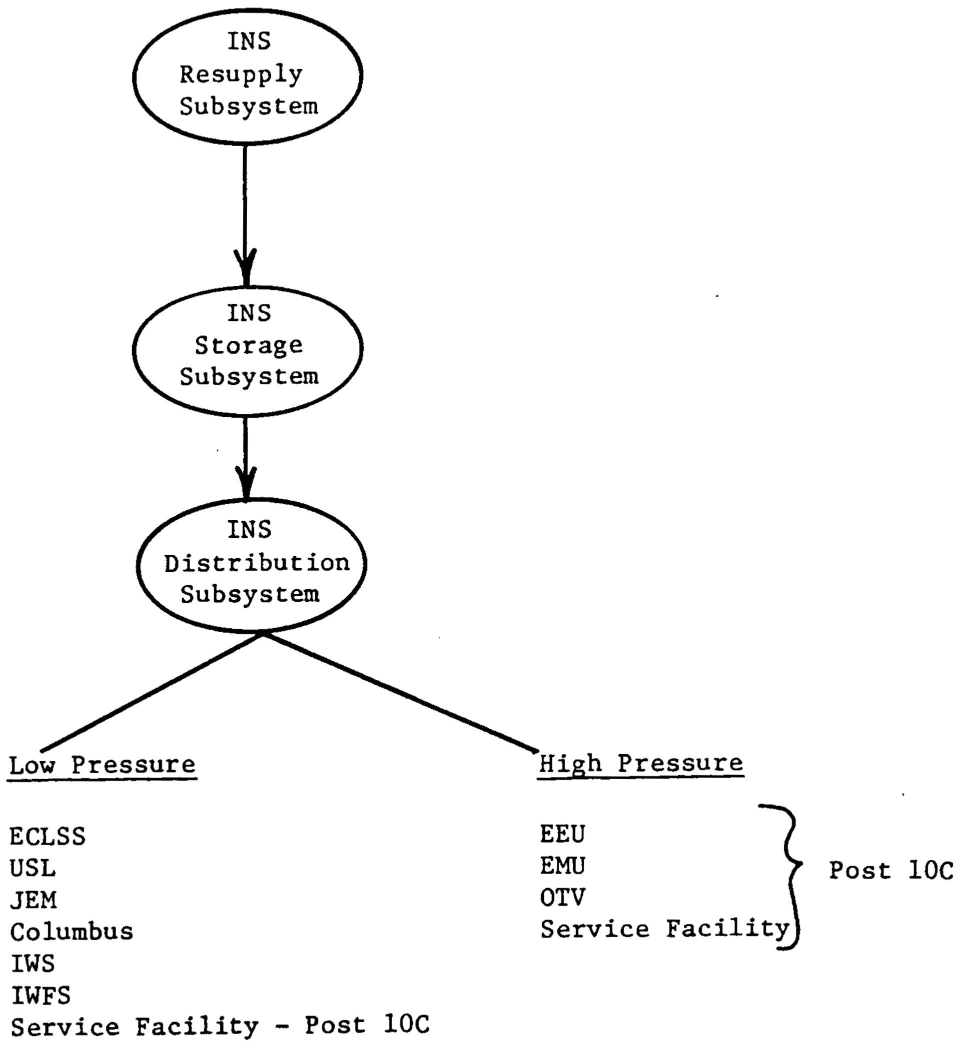

Figure 8.3-1 Integrated Nitrogen System Functional Diagram

Table 8.3-1 Integrated Nitrogen System Inventory Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS)		RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
						MEAN	MAX			
80	INS	DISTRIBUTION	GN2	N/A	TBD TBD	TBD	TBD	UNPRESSURIZED LOGISTICS MODULE	GN2	SEE SECTION 8.1.3
81	INS	DISTRIBUTION	GN2	N/A	TBD TBD	TBD	TBD	UNPRESSURIZED LOGISTICS MODULE	GN2	SEE SECTION 8.1.3
82	INS	DISTRIBUTION	GN2	N/A	TBD TBD	TBD	TBD	UNPRESSURIZED LOGISTICS MODULE	GN2	SEE SECTION 8.1.3
83	INS	DISTRIBUTION	GN2	N/A	TBD TBD	TBD	TBD	UNPRESSURIZED LOGISTICS MODULE	GN2	SEE SECTION 8.1.3
84	INS	DISTRIBUTION	GN2	N/A	TBD TBD	TBD	TBD	UNPRESSURIZED LOGISTICS MODULE	GN2	SEE SECTION 8.1.3
85	INS	DISTRIBUTION	GN2	N/A	TBD TBD	TBD	TBD	UNPRESSURIZED LOGISTICS MODULE	GN2	SEE SECTION 8.1.3
78	INS	RESUPPLY	GN2	TBD	TBD TBD	TBD	TBD	UNPRESSURIZED LOGISTICS MODULE	GN2	PER PALLET DATA, 2 PALLETS ON STATION BROUGHT UP BY THE UNPRESSURIZED LOGISTICS MODULE SEE 8.1.1
79	INS	STORAGE	GN2	780	TBD TBD	N/A	N/A	UNPRESSURIZED LOGISTICS MODULE	GN2	PER PALLET DATA, 2 IDENTICAL PALLETS ON STATION, SEE SECTION 8.1.2

Table 8.3-2 Integrated Nitrogen System Fluid Interface Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	INLET AND OUTLET FLUID CONDITIONS				METHOD OF WASTE MANAGEMENT	FAILURE TOLERANCE	REMARKS
				FROM TO	PRESSURE (PSIA)	TEMP. (F)	LINE SIZES (INCHES)			
80	INS	DISTRIBUTION	GN2	INS, RESUPPLY ECLSS	4000 250/750	70 70	TBD TBD	N/A	SINGLE	SEE SECTION 8.1.3
81	INS	DISTRIBUTION	GN2	INS, RESUPPLY IWS	4000 250/750	70 70	TBD TBD	N/A	SINGLE	SEE SECTION 8.1.3
82	INS	DISTRIBUTION	GN2	INS, RESUPPLY IWFS	4000 250/750	70 70	TBD TBD	N/A	SINGLE	SEE SECTION 8.1.3
83	INS	DISTRIBUTION	GN2	INS, RESUPPLY USL	4000 250/750	70 70	TBD TBD	N/A	SINGLE	SEE SECTION 8.1.3
84	INS	DISTRIBUTION	GN2	INS, RESUPPLY JEM	4000 250/750	70 70	TBD TBD	N/A	SINGLE	SEE SECTION 8.1.3
85	INS	DISTRIBUTION	GN2	INS, RESUPPLY COLUMBUS	4000 250/750	70 70	TBD TBD	N/A	SINGLE	SEE SECTION 8.1.3
78	INS	RESUPPLY	GN2	INS, RESUPPLY INS, DISTRIBUTION	4000 4000	70 70	TBD TBD	N/A	SINGLE	PER PALLET DATA, 2 PALLETS ON STATION BROUGHT UP BY THE UNPRESSURIZED LOGISTICS MODULE SEE 8.1.1
79	INS	STORAGE	GN2	INS, RESUPPLY INS, DISTRIBUTION	4000 4000	70 70	TBD TBD	N/A	SINGLE	PER PALLET DATA, 2 PALLETS ON STATION, W/BOTH PALLETS THREE FAILURE TOLERANCE EXISTS.SEE 8.1.2

8.3.1 Resupply Subsystem

The INS resupply subsystem will consist of the tankage, mounting hardware, conditioning, thermal control, transfer, and control and monitoring hardware for delivery of the nitrogen to the Space Station (SS). The resupply hardware will be integrated and delivered to the SS by the Logistics System. The INS resupply subsystem will be capable of being located at two interface locations on the truss that are optimized for on-orbit operations including EVA operations. The INS resupply subsystem performs the dual function of resupply and storage of the nitrogen delivered to SS to satisfy all user requirements. The resupply subsystem will be a GN_2 blowdown supply system that at full tankage conditions is at 3000 to 4000 psi to optimize tankage mass fraction. At depletion of the first pallet the second resupply pallet mounted on station would take over the resupply operation and the depleted pallet would be removed and replaced. Figure 8.3-2 shows the schematic of the INS resupply subsystem with the corresponding components listing shown as Table 8.3-3.

8.3.2 Storage Subsystem

The INS storage subsystem will provide sufficient storage capacity to satisfy emergency ECLSS requirements for hyperbaric airlock and safe-haven operations. The INS storage subsystem is located external to the modules in the truss. Each pallet will retain 780 lbm of GN_2 stored at 3000 to 4000 psi and used only for safe haven or hyperbaric airlock operations. The schematic is shown as Figure 8.3-3 with the corresponding components list shown as Table 8.3-4.

8.3.3 Distribution Subsystem

The INS distribution subsystem will transfer the nitrogen from the INS storage subsystem at 3000 to 4000 psi and will reduce the pressure to 250 to 750 psi for low pressure use and will then route the nitrogen to the various user interfaces. The INS distribution subsystem consists of the plumbing, connectors, thermal control, conditioning, structural attachment, and control and monitoring hardware to distribute nitrogen to both high and low pressure users. All high pressure users at the present time are post IOC and therefore the INS is scarred for eventual high pressure applications as indicated. The schematic shown as Figure 8.3-4 reflects the potential hardware to reduce the 3000 to 4000 psi supply to 3000 psi for use, but is only a tentative solution pending further requirement definition. For this reason the component listing shown as Table 8.3-5 list the scarring requirements and not the potential future growth hardware. The INS distribution subsystem and will be located both internal to the pressurized portions of SS as well as eventual future growth externally along the truss system to supply the Servicing Facility and OMV requirements.

8.4 INTEGRATED NITROGEN SYSTEM REFERENCES

1) Architectural Control Document Fluid Management System; Section 1: Integrated Nitrogen System, NASA JSC 30264. December 1, 1986.

2) Space Station Program Definition and Requirements, Section 3, System Requirements Rev. A, SS-SRD-0001. January 12, 1987.

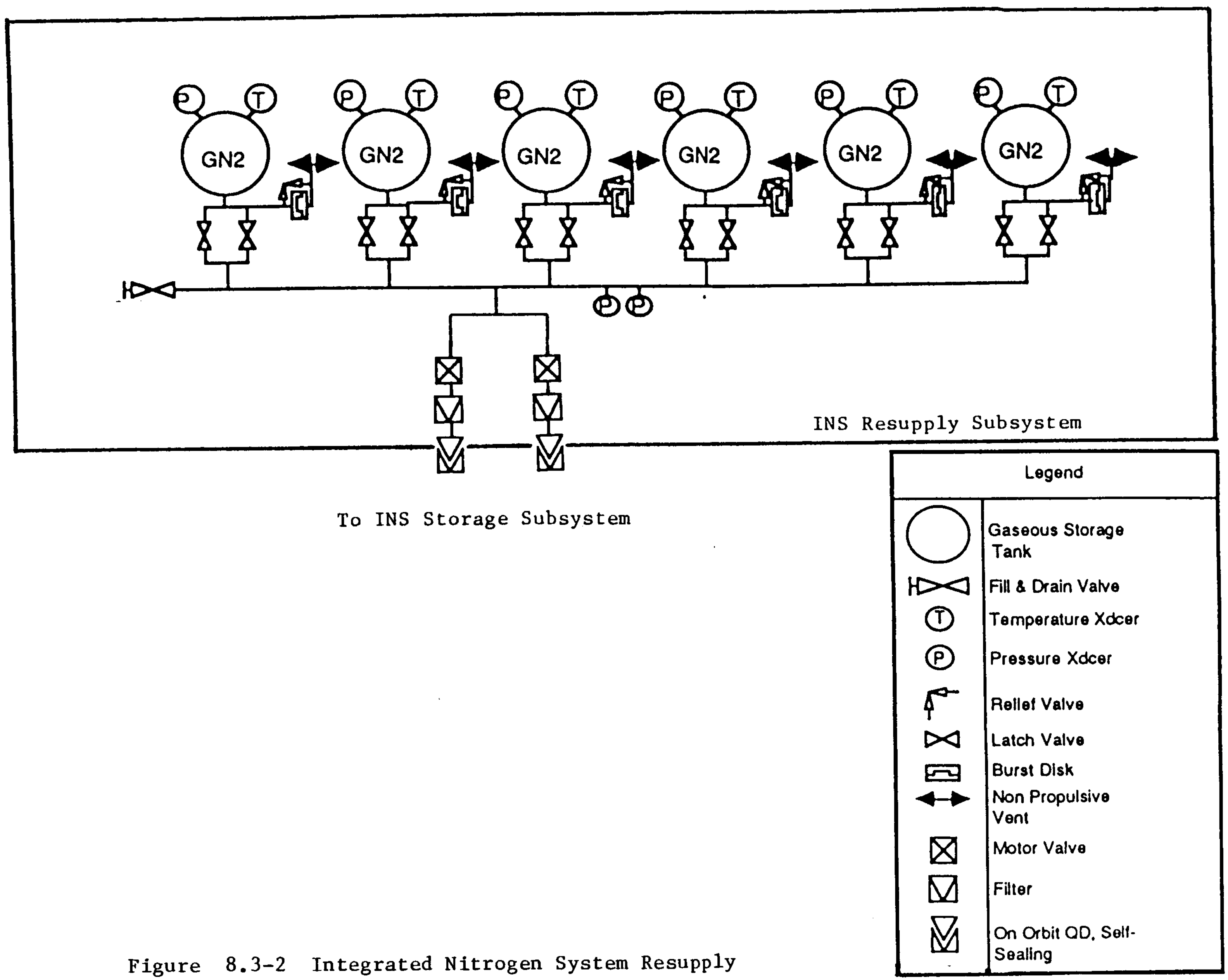

Figure 8.3-2 Integrated Nitrogen System Resupply Subsystem Schematic

Table 8.3-3 Integrated Nitrogen System Resupply Subsystem Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
125	INS,RS	DISCONNECT,	2	TBD	4000	GN2	TBD	TBD	TBD
124	INS,RS	FILTER, INLINE	2	TBD	4000	GN2	TBD	TBD	TBD
123	INS,RS	MISC, VENT ASSY, NON-PROPULSIVE	6	TBD	4000	GN2	TBD	TBD	TBD
118	INS,RS	PRESSURE VESSEL,	6	TBD	4000	GN2	TBD	TBD	TBD
126	INS,RS	SENSOR, PRESSURE	8	TBD	4000	GN2	TBD	TBD	TBD
127	INS,RS	SENSOR, TEMPERATURE	6	TBD	4000	GN2	TBD	TBD	TBD
119	INS,RS	VALVE, MANUAL, SERVICE	1	TBD	4000	GN2	TBD	TBD	TBD
122	INS,RS	VALVE, RELIEF W/BD	6	TBD	4000	GN2	TBD	TBD	TBD
120	INS,RS	VALVE, SOLENOID, LATCHING	12	TBD	4000	GN2	TBD	TBD	TBD
121	INS,RS	VALVE, TORQUE MOTOR	2	TBD	4000	GN2	TBD	TBD	TBD

Table 8.3-4 Integrated Nitrogen System Storage Subsystem Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
134	INS,SS	DISCONNECT,	4	TBD	4000	GN2	TBD	TBD	TBD
133	INS,SS	FILTER, INLINE	4	TBD	4000	GN2	TBD	TBD	TBD
132	INS,SS	MISC, VENT ASSY, NON-PROPULSIVE	3	TBD	4000	GN2	TBD	TBD	TBD
128	INS,SS	PRESSURE VESSEL,	3	TBD	4000	GN2	TBD	TBD	TBD
135	INS,SS	SENSOR, PRESSURE	5	TBD	4000	GN2	TBD	TBD	TBD
136	INS,SS	SENSOR, TEMPERATURE	3	TBD	4000	GN2	TBD	TBD	TBD
131	INS,SS	VALVE, RELIEF W/BD	3	TBD	4000	GN2	TBD	TBD	TBD
129	INS,SS	VALVE, SOLENOID, LATCHING	6	TBD	4000	GN2	TBD	TBD	TBD
130	INS,SS	VALVE, TORQUE MOTOR	4	TBD	4000	GN2	TBD	TBD	TBD

Table 8.3-5 Integrated Nitrogen System Distribution Subsystem Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
142	INS,DS	DISCONNECT,	2	TBD	4000	GN2	TBD	TBD	TBD
141	INS,DS	FILTER, INLINE	4	TBD	4000	GN2	TBD	TBD	TBD
143	INS,DS	REGULATOR, ELECTRONIC, W/RELIEF	2	TBD	4000/750	GN2	TBD	TBD	TBD
144	INS,DS	SENSOR, PRESSURE	2	TBD	4000	GN2	TBD	TBD	TBD
145	INS,DS	SENSOR, PRESSURE	2	TBD	750	GN2	TBD	TBD	TBD
146	INS,DS	SENSOR, TEMPERATURE	2	TBD	750	GN2	TBD	TBD	TBD
139	INS,DS	VALVE, SOLENOID, LATCHING	3	TBD	4000	GN2	TBD	TBD	TBD
140	INS,DS	VALVE, SOLENOID, LATCHING	3	TBD	750	GN2	TBD	TBD	TBD
137	INS,DS	VALVE, TORQUE MOTOR	2	TBD	4000	GN2	TBD	TBD	TBD
138	INS,DS	VALVE, TORQUE MOTOR	12	TBD	750	GN2	TBD	TBD	TBD

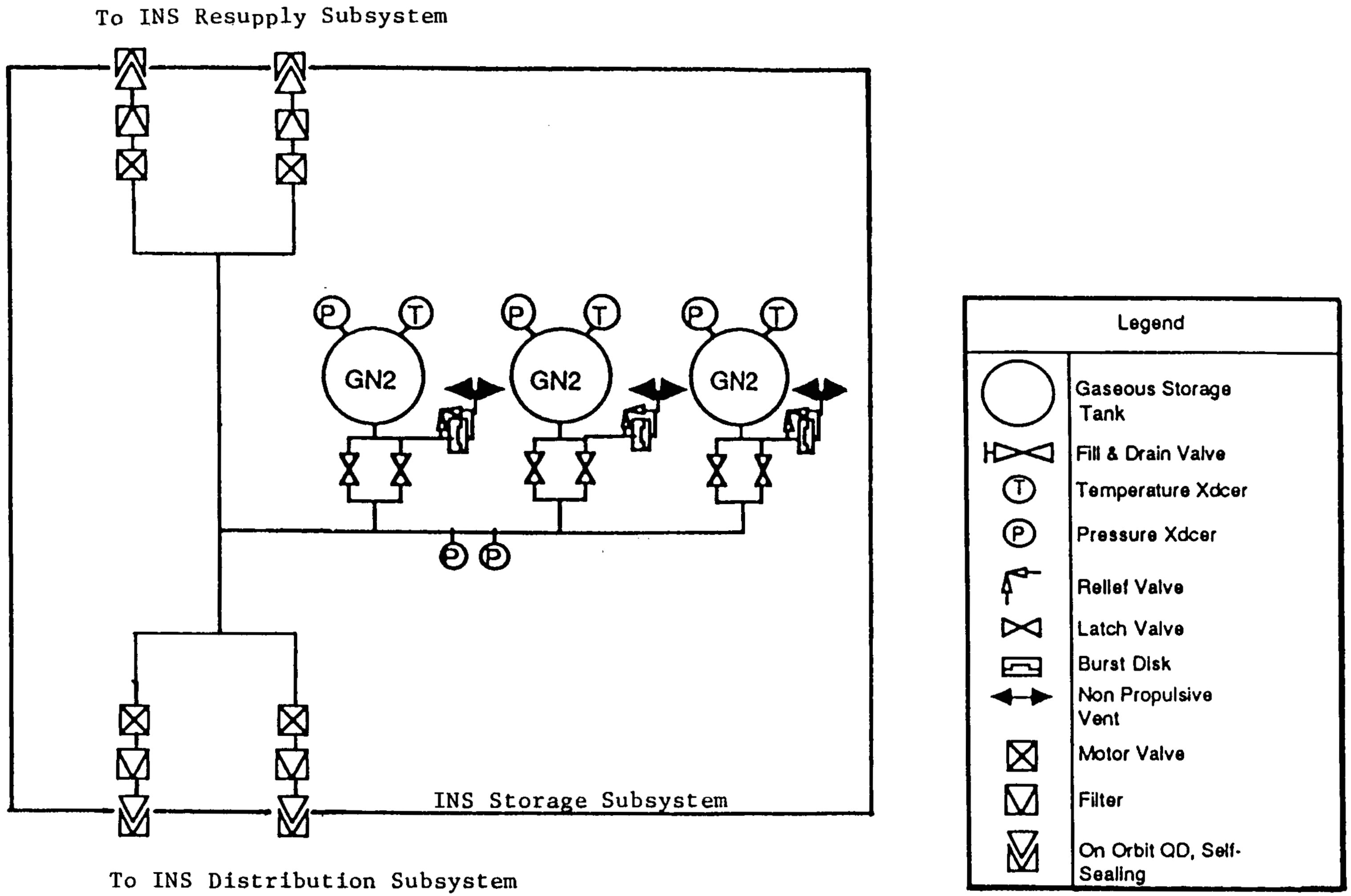

Figure 8.3-3 Integrated Nitrogen System Storage Subsystem Schematic

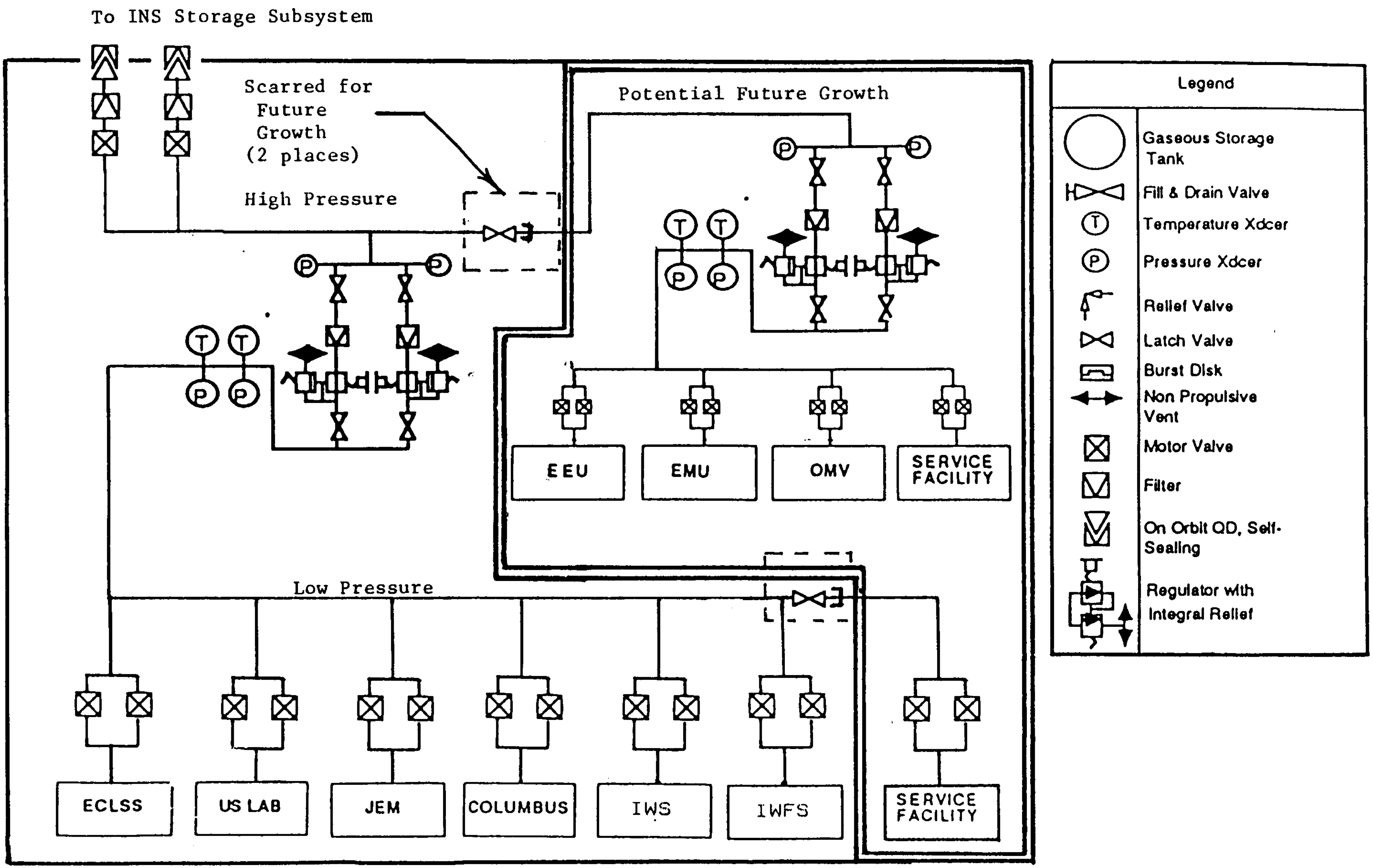

Figure 8.3-4 Integrated Nitrogen System Distribution Subsystem

9.0 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM

9.1 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM OVERALL REQUIREMENTS

The Environmental Control and Life Support System (ECLSS) is an integrated system that services the entire Space Station. It provides a safe and habitable environment for the entire crew, including the international modules. Due to the high degree of commonality in the system, the ECLSS provides each module with the necessary environmental control. The system also interfaces with the nodes, airlocks, and logistics carrier. Because the ECLSS is functionally a regenerative closed system, only those fluids and gases piped into and out of the entire system will be discussed and quantitatively presented. The function and operation of each component will be briefly presented. The primary function of the ECLSS is to provide a shirt sleeve environment for the Space Station crew members. The ECLSS is divided into six subsystems; 1) Temperature and Humidity Control (THC), 2) Atmosphere Control and Supply (ACS), 3) Atmosphere Revitalization (AR), 4) Fire Detection and Suppression (FDS), 5) Water Recovery and Management (WRM) and 6) the Waste Management (WM). Fluid requirements for these subsystems are presented in Table 9.2-1.

9.2 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM FLUID SUBSYSTEMS REQUIREMENTS

Table 9.2-1 ECLSS Subsystem Fluid Requirements

ECLSS Subsystem	Fluid Requirements
Temperature and Humidity Control	1) Cabin air temperature and humidity control. (nominal module temperature range 65^oF - 80^oF) 2) Intermodule ventilation. 3) Avionics Air Cooling.
Atmospheric Control and Supply	1) O_2/N_2 pressure control a) PPO_2; 2.83 psia to 3.35 psia b) PPN_2; 11.35 psia to 11.87 psia c) Total pressure; 14.7 $\pm$ .2 psia 2) Vent and relief. 3) O_2/N_2 storage and distribution.
Atmospheric Revitalization	1) CO_2 removal through regenerative process. 2) CO_2 reduction (Bosch/Sabatier). 3) O_2 generation (KOH Static Feed). Electrolysis Unit as primary source of O_2. 4) Contaminant control. 5) Contaminant monitoring.
Fire Detection and Suppression	1) Fire detection. 2) Fire suppression. 3) Crew protection.

Table 9.2-1 ECLSS Subsystem Fluid Requirements (Continued)

Water Recovery and Management	1)	Potable and hygiene water processing. Collect, process and dispense water to meet crew needs.
	2)	Urine/flush processing. Process and dispose of urine an fecal matter from crew members.
	3)	Water storage and distribution. Provide a closed-loop recovery system for potable and hygiene water. (TIMES)
	4)	Water thermal conditioning.
	5)	Water quality control and monitoring. Ensure proper water quality through pretreatment, post-treatment, and monitoring.
Waste Management	1)	Trash collecting and processing.
	2)	General housekeeping.
	3)	Commode and Urinal.
	4)	Storage of brine, solid carbon, and feces canister in pressurized logistics carrier.

9.3 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM FLUID SUBSYSTEMS DESCRIPTIONS AND CONFIGURATIONS

The primary function of the ECLSS system will be to maintain a habitable environment for the entire station. A schematic of the entire ECLSS is shown in Figure 9.3-1. The system will be comprised of six separate subsystems including a Temperature and Humidity Control (THC), Atmosphere Control and Supply (ACS), Atmospheric Revitalization (AR), Fire Detection and Suppression (FDS), Water Recovery and Management, and Waste Management. Each subsystem will interface with one or all the other subsystems so that they will comprise a functionally closed loop system that will require scheduled fluid resupply of nitrogen only, for leakage makeup and airlock losses.

The primary ECLSS user interfaces are in areas of avionics air cooling and air contamination control. The thermal control interfaces include cabin heat exchangers, avionics heat exchangers, and air revitalization equipment. Manned Systems interfaces include the commode, shower, hand wash, and both clothes and dish washers.

Tables 9.3-1 and 9.3-2 provide fluid storage, resupply and interface requirements. Table 9.3-3 provides a list of all the components included in the ECLSS.

9.3.1 Temperature and Humidity Control (THC) Subsystem

The THC subsystem will be capable of providing three primary functions. The first will be to remove heat produced by equipment racks through the avionics air cooling system. The second will be to provide intermodule ventilation by moving air from one cabin to the next to ensure complete mixing of the station air. Finally, the THC will provide a shirt-sleeve environment in the station. By maintaining the required nominal humidity level, the cabin cooling package will provide condensate that is passed to the condensate water loop of the Water Recovery and Management (WRM) subsystem.

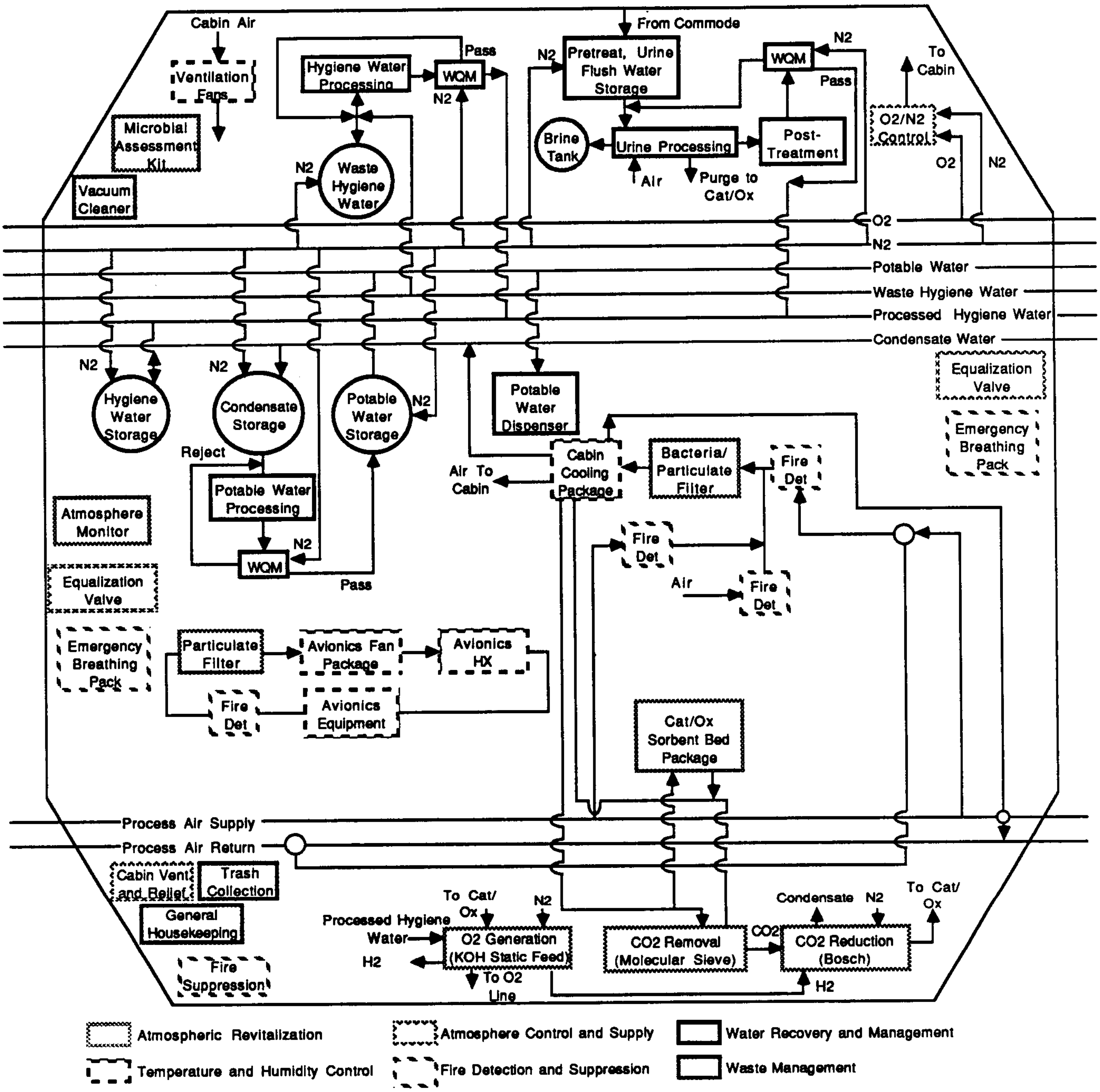

Figure 9.3-1 Environmental Control and Life Support System (ECLSS) Schematic

Table 9.3-1 ECLSS Fluid Inventory Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	QUANTITY STORED	USAGE RATE (LB/HR)	RESUPPLY QUANTITY (LB/90 DAYS) MEAN	RESUPPLY QUANTITY (LB/90 DAYS) MAX	RESUPPLY METHOD	FLUID COMPOSITION	REMARKS
69	ECLSS	ACS	GN2	N/A	LEAKAGE MAKEUP	432		FLUID TRANSFER FROM INS	PURE	MODULE LEAKAGE & AIRLOCK LOSSES
70	ECLSS	ACS	GO2	216	LEAKAGE MAKEUP			ELECTROLYSIS	PURE	MODULE LEAKAGE & AIRLOCK LOSSES
71	ECLSS	WM	BRINE	476	0.220 NOM			TAKE TO EARTH	38% SOLIDS	STORED FOR TRANSPORT TO EARTH
72	ECLSS	WRM	H2O		0.046 NOM			FOOD FROM PLC		FROM WET FOOD
73	ECLSS	WRM	H2O		0.310			ECLSS EXCESS	POTABLE	USING BOSCH CO2 REDUCTION
74	ECLSS	WRM	GH2		0.018			EXCESS FROM ELECTROLYSIS	PURE	USING BOSCH CO2 REDUCTION
75	ECLSS	WRM	CARBON, SOLID		0.203			FROM BOSCH		USING BOSCH CO2 REDUCTION
76	ECLSS	WRM	H2O		0.087			ECLSS EXCESS	POTABLE	USING SABATIER CO2 REDUCTION
77	ECLSS	WRM	CO2/CH4		0.443			FROM SABATIER		NOT STOICHIOMETRIC REACTION IN SABATIER

Table 9.3-2 ECLSS Fluid Interface Requirements

ID NO.	FLUID SYSTEM	FLUID SUBSYSTEM	FLUID TYPE	INLET AND OUTLET FLUID CONDITIONS: FROM / TO	PRESSURE (PSIA)	TEMP. (F)	LINE SIZES (INCHES)	METHOD OF WASTE MANAGEMENT	FAILURE TOLERANCE	REMARKS
69	ECLSS	ACS	GN2	INS MODULE/NODE/AL	750 OR 250 14.7	70 70	3/8 3/8	LOSSES AND VENTING		DURING SAFE-HAVEN AND HYPERBARIC AIRLOCK OPERATIONS THE SUPPLY JUMPS FROM 250 TO 750 PSIA
70	ECLSS	ACS	GO2	O2 STORAGE PALLET MODULE/NODE/AL	180-200 14.7	TBD AMBIENT	3/8 3/8	LOSSES & VENTING		
71	ECLSS	WM	BRINE	TIMES PLC				STORE IN TANKS TO TRANSPORT		
72	ECLSS	WRM	H2O	FOOD URINE PROCESSING				TIMES		
73	ECLSS	WRM	H2O	ECLSS IWS	44.9 20-30	AMBIENT AMBIENT				BOSCH
74	ECLSS	WRM	GH2	KOH ELECTROLYSIS IWFS	180 100	200 90		IWFS		BOSCH, STORED IN HYDRIDE TANK
75	ECLSS	WRM	CARBON, SOLID	BOSCH PLC		980-1340 AMBIENT		STORE IN PLC		BOSCH
76	ECLSS	WRM	H2O	ECLSS IWS	44.9 20-30	AMBIENT AMBIENT				SABATIER
77	ECLSS	WRM	CO2/CH4	SABATIER IWFS	TBD 14.7	600-900 70		IWFS		SABATIER

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Table 9.3-3 ECLSS Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
115	ECLSS,ACS	MISC, CONTROL, N2 RESUPPLY PRESSURE	1	TBD	TBD	GN2	57.0	TBD	TBD
89	ECLSS,ACS	MISC, PRESSURE CONTROL SYSTEM	5	.375	250	GO2, GN2	50.0	TBD	TBD
113	ECLSS,ACS	MISC, REFRIGERATOR/FREEZER	3	TBD	TBD	TBD	586.0	TBD	TBD
114	ECLSS,ACS	PRESSURE VESSEL,	2	TBD	TBD	LN2	170.0	TBD	TBD
87	ECLSS,ACS	REGULATOR, DOWNSTREAM	2	.375	4000	GN2	5.0	TBD	TBD
90	ECLSS,ACS	VALVE, EQUALIZATION	9	TBD	14.9	AIR	6.0	TBD	TBD
88	ECLSS,ACS	VALVE, RELIEF	5	TBD	14.9	AIR	3.8	TBD	TBD
92	ECLSS,AR	FILTER, AVIONICS PARTICULATE	4	TBD	14.9	AIR	17.0	TBD	TBD
95	ECLSS,AR	FILTER, BACTERIA/PARTICULATE	7	TBD	14.9	AIR	60.0	TBD	TBD
99	ECLSS,AR	MISC, CATALYTIC OXIDIZER	4	TBD	30	AIR	80.0	TBD	TBD
94	ECLSS,AR	MISC, CO2 REDUCTION, BOSCH	4	.25	30	AIR	328.0	TBD	TBD
97	ECLSS,AR	MISC, ELECTROLYSIS UNIT, KOH	4	TBD	200	H2O, GO2, GH2	232.0	TBD	TBD
96	ECLSS,AR	MISC, MOLECULAR SIEVE, 4-BED	4	TBD	30	AIR, CO2	322.0	TBD	TBD
98	ECLSS,AR	MISC, MONITOR, ATMOSPHERE	5	TBD	14.9	AIR	57.0	TBD	TBD
93	ECLSS,AR	MISC, SORBENT BED	4	TBD	30	AIR	90.0	TBD	TBD
101	ECLSS,FDS	MISC, CONTROLLER, PYRO	7	N/A	500	HALON 1301	2.0	TBD	TBD
100	ECLSS,FDS	PRESSURE VESSEL, FIRE SUPPRESSANT	76	TBD	500	HALON 1301	8.0	TBD	TBD
91	ECLSS,THC	MISC, CABIN COOLING PKG	7	TBD	14.9	AIR	123.0	TBD	TBD
116	ECLSS,WM	MISC, BRINE STORAGE	6	TBD	TBD	URINE BRINE	33.0	TBD	TBD
117	ECLSS,WM	MISC, FECAL STORAGE	1	TBD	TBD	FECES	52.0	TBD	TBD
103	ECLSS,WRM	MISC, DISPENSER, POTABLE WATER	2	TBD	44.9	H2O	41.0	TBD	TBD
109	ECLSS,WRM	MISC, EYEWASH	1	TBD	44.9	H2O	1.0	TBD	TBD
106	ECLSS,WRM	MISC, MONITOR, WATER QUALITY	8	TBD	44.9	H2O	68.0	TBD	TBD
108	ECLSS,WRM	MISC, PROCESSING UNIT, POTABLE WATER	4	TBD	44.9	H2O	77.0	TBD	TBD
107	ECLSS,WRM	MISC, PROCESSING UNIT, WASTE HYGIENE	2	TBD	44.9	H2O	202.0	TBD	TBD
105	ECLSS,WRM	PRESSURE VESSEL, CONDENSATE WATER	2	TBD	44.9	H2O	108.0	TBD	TBD
104	ECLSS,WRM	PRESSURE VESSEL, EMERGENCY WASH WATER	2	TBD	44.9	H2O	128.0	TBD	TBD
112	ECLSS,WRM	PRESSURE VESSEL, HYGIENE WATER	1	TBD	44.9	H2O	1000.0	TBD	TBD
102	ECLSS,WRM	PRESSURE VESSEL, POTABLE WATER	4	TBD	44.9	H2O	166.0	TBD	TBD
110	ECLSS,WRM	PRESSURE VESSEL, PROCESSED HYGIENE WATER	2	TBD	44.9	H2O	315.0	TBD	TBD
111	ECLSS,WRM	PRESSURE VESSEL, WASTE HYGIENE WATER	2	TBD	44.9	H2O	292.5	TBD	TBD

9.3.2 Atmosphere Control and Supply (ACS) Subsystem

The ACS subsystem will maintain the partial and total pressures of O_2 and N_2 in the modules and will be responsible for storage and distribution of both O_2 and N_2. The ACS subsystem provides N_2 for leakage makeup, airlock losses, tank back pressurization/water transfer, and purge for the air revitalization and waste management systems.

The oxygen required for daily use, i.e., leakage makeup and airlock uses will be generated by the electrolysis unit in the Atmospheric Revitalization (AR) subsystem. This oxygen will be stored in accumulators at 3000 psia. The nitrogen required for daily use will be stored as part of the Integrated Nitrogen System (INS) resupply subsystem (see Section 8.1-1). Nitrogen storage will also be provided for safe-haven or emergency conditions as part of the INS storage subsystem. There will be an oxygen storage tank for safe-haven or emergency conditions that will require resupply only if the oxygen is exhausted during adverse conditions. The oxygen and nitrogen will be distributed to the ACS subsystem as needed at 180-200 psia and 200-250 psia respectively.

9.3.3 Atmospheric Revitalization (AR) Subsystem

The AR subsystem will perform several vital functions. The first will be to both monitor and control any contaminants in the modules. The other functions will interface with both the WM and ACS subsystems. The AR subsystem will generate oxygen using a KOH Static Feed Electrolysis Unit. To do this, the unit will use processed hygiene water from the WRM subsystem and N_2 from the ACS subsystem. The oxygen produced will be transferred to the ACS O_2 line, and the hydrogen will be transferred to the CO_2 reduction system as needed, with the remaining H_2 going to the Integrated Waste Fluid System.

The AR subsystem will also remove CO_2 from the atmosphere using a Four-Bed Molecular Sieve. The CO_2 that is collected during the CO_2 removal in the molecular sieve will then be reduced in the CO_2 reduction unit. This will be accomplished using either a Bosch Carbon Reactor or a Sabatier Methanation Reactor Subsystem.

During the CO_2 removal process in the Bosch, the water condensed will be put into the WRM condensate water line. The hydrogen required for the reaction will be acquired from the electrolysis unit.

As with the Bosch, the condensed water from the Sabatier process will be transferred into the condensate line of the WRM subsystem. The methane will be transferred to the Integrated Waste Fluid System for appropriate disposal.

9.3.4 Fire Detection and Suppression (FDS) Subsystem

The FDS subsystem will be fully charged when brought onboard and will not require resupply. Air from the cabin and the process air supply will be passed through the FDS subsystem for detection of possible fires before entering the cabin cooling package. The FDS subsystem will not alter the air in any way. The air will return to the cabin or process air return duct, or sent to the CO_2 removal system as needed.

9.3.5 Water Recovery and Management (WRM) Subsystem

The WRM subsystem will interface with the THC, the ACS, and the AR subsystems. The WRM will be a closed loop system that does not require resupply. In fact, the WRM subsystem will supply excess water to the integrated waste system. The source of the water for the WRM will be in the form of moisture in the food. The moisture will enter the WRM subsystem through perspiration and urine. The perspiration will condense in the cabin cooling loop and enter the condensate loop to be processed for potable water. The urine will enter the urine processing loop.

For the urine processing, the TIMES, a distillation-based unit using membrane evaporation for unique phase separation will be used. Waste water will enter the unit and be preheated by a regenerative heat exchanger, filtered and heated by a Thermoelectric Device (TED) to operating temperature. The waste water will be passed through the Hollow Fiber Membrane (HFM) evaporator module where a portion of the consultant water will be evaporated into steam. The bulk of water not turned to steam will continuously recycled through the module until the solids concentration reaches a predetermined limiting level at which time this brine will be dumped to a collection tank. The brine collection tank will be part of the waste management subsystem. The tanks will be located near the TIMES and changed out when full. The full brine tanks will be stored in the Pressurized Logistics Module. The product steam will flow to the cold side of the TED where most of the steam will be condensed and the latent heat reclaimed and transferred back to the waste water heating side of the TED.

Additional condensation will occur in the regenerative heat exchanger and complete steam condensation will occur in the fan-cooled heat exchanger. The presence of noncondensible gases and condensate will result in a two-phase mixture requiring a gas-liquid separator. The separated noncondensible gases will be vented to a vacuum source and the pressurized condensate checked for conductivity. Acceptable condensate will be passed to the processed hygiene loop. Reject water will be returned to the recycle loop. A pulse valve/pressure sensor combination will ensure optimum operating steam pressure in the evaporator. A gas orifice will be provided to minimize pressure pulses.

The processed hygiene water will be used for wash purposes and water electrolysis. The hygiene water can be put back into the potable loop by latent loads from laundry, dishwash, and hygiene water in the form of condensate. Excess potable can also be transferred to the hygiene loop if needed.

9.3.6 Waste Management (WM) Subsystem

The WM subsystem will include the commode and urinal which interface with WRM subsystem. The WM subsystem will provide storage for the waste products of both the WRM and AR subsystems. The WM subsystem will store the urine brine, feces canisters, and carbon produced in the CO_2 reduction unit in the pressurized logistics carrier.

9.4 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM REFERENCES

Space Station Definition and Preliminary Design, WP-01, Book 3 - U.S. Lab Module, SSP-MMC-00031 (Rev. B) NAS8-36525. Martin Marietta Denver Aerospace, October 1986.

Space Station Definition and Preliminary Design, WP-01, Book 10 Airlocks. SSP-MMC-00031 (Rev. A), NAS8-36525. Martin Marietta Denver Aerospace, June 1986.

Larkins, J. T., Wagner, R. C., and Gopikanth, M. L., A Space Station Utility - Static Feed Electrolyzer. Presented at ICES Conference, Life Systems, Inc., July 1986.

Data submitted by Jim Reuter, Marshall Space Flight Center, Huntsville, AL, April 30, 1987.

Fluids Technical Integration Panel Data. Presented at Marshall Space Flight Center, Huntsville, AL, October 1986.

10.0 THERMAL CONTROL SYSTEM

10.1 THERMAL CONTROL SYSTEM OVERALL REQUIREMENTS

The Thermal Control System shall be an integrated system which maintains structures, ancillary compartments, components, subsystems and user payloads within their specified thermal limits. The TCS will be a closed loop system that does not require scheduled fluid resupply and will be considered independent from the integrated fluid systems. Accommodations will be made in the system TCS for fluid leakage and system purging to remedy system contamination. Overall thermal control system requirements are provided in Table 10.1-1.

Table 10.1-1 Thermal Control System Overall Requirements

1) Structures/Environmental Protection
   - Maintain Space Station Program Element (SSPE) structures, systems and subsystems within required temperature ranges using passive thermal control techniques or by efficient integration with the acquisition and transport subsystems.

2) Waste Heat Acquisition/Transport
   - Provide waste heat acquisition and transport within each pressurized element.
   - Collect, transport, and where feasible, utilize waste heat generated from Station elements for use in airlocks, interconnects and intramodular elements.

3) Heat Rejection
   - United States modules shall provide a low temperature heat sink to support requirements for refrigerators and freezers.
   - Heat acquisition and transport systems shall provide continual service during all normal vehicle operating environments and orientations to U.S. pressurized elements.

10.2 THERMAL CONTROL SYSTEM FLUID SYSTEM REQUIREMENTS

The TCS design is required to provide modular growth capability and on-orbit reconfiguration capability to accommodate multiple heat loads of varying magnitudes, heat flux densities, temperature levels and locations. The U.S. Modules and attached elements shall provide heat collection, transport and rejection capabilities at the levels provided in Table 10.2-1.

Table 10.2-1 Thermal Control System Heat Rejection Capability

Element	Thermal Load (kW)	Temperature Range (^{o}F)
Habitation		
Internal Loop	25	40 - 120
Resource Node	25	40 - 120
United States Lab		
Internal Loop	50	40 - 120
Resource Node	25	40 - 120
Logistics	10	40 - 120
Airlock	TBD	TBD
Hyperbaric Airlock	TBD	TBD
Resource Node	TBD	TBD

Interfaces

The thermal design shall easily interface with equipment, subsystems and payloads. The interface shall not, where practical, require making and/or breaking of fluid connections for maintenance and refurbishment or experiment installation.

Manned Pressurized Element

Thermal acquisition and transport systems shall be capable of transporting the elements waste heat to a central thermal bus interface. Internal loop designs shall be based upon a single phase water system. Heat rejection/transfer to the station central thermal bus will be through bus interface heat exchangers attached externally to the elements. This method will be used by both U.S. Manned Pressurized Elements and International Modules. The exception to this will be the Logistics Module/Airlock Internal Thermal Support Loop which will be connected to the central thermal bus through an internal interface with a core station internal loop and the resource nodes which will be connected TBD.

Attached Elements

For pressurized Logistics Modules, Airlocks and Hyperbaric Airlocks attached to the resource node, thermal acquisition and transport will be provided at the resource node/element interface by an internal water system connected to the thermal transport bus located in the resource node. A heat sink for the refrigeration and freezer, located in the Logistics Module, will be provided at the node/element interface. For pressurized payloads attached directly to the node, thermal acquisition will be through central thermal bus interface heat exchangers attached externally to the payload.

Leak Detection

A method for detecting, isolating, and repairing leaks within the system is required. Where practical, provisions will be made to remove and replace failed fluid loop components without draining and reservicing the fluid loops.

Coolant Fluids

The coolant fluid to be used within the pressurized manned environment shall be water or some other non-toxic fluid.

The coolant fluid to be used outside of the pressurized manned environment shall be TBD.

10.3 THERMAL CONTROL SYSTEM FLUID SYSTEM DESCRIPTION AND CONFIGURATION

Manned Pressurized Elements

The TCS of the U.S. Manned pressurized elements and international modules will be similar in configuration to the USL Thermal Control System shown in Figure 10.3-1. The system will contain three basic loops; a primary experiment loop, an attached payload loop and a refrigeration/freezer loop.

The primary experiment loop will be a pumped single-phase water coolant loop which will service all four rack banks and will be capable of rejecting 50 kW of waste heat. The 70°F loop will collect waste heat from the avionics heat exchanger as well as from subsystem/experiment cold plates and/or heat exchangers mounted in the racks. The 35°F loop will collect waste heat from the cabin condensing heat exchanger as well as from subsystem/experiment cold plates and/or heat exchangers. The 35°F coolant interface will only be provided down one side of the module due to its limited demand, primarily from the biological experiments. USL waste heat from this primary experiment loop will be transferred to the Space Station Heat Rejection and Transport System (HR&T) through 70°F and 35°F central bus heat exchangers mounted on the exterior of the USL endcone structure. Redundant pump packages will be provided for safety.

An attached payload loop, sized for 25 kW, will be provided to cool equipment in USL adjacent nodes and/or interconnects. This loop will also be pumped single-phase water.

Refrigerator/freezer services are required in the USL. Low temperature body mounted radiators will be provided to reject the heat necessary to meet the -30°C freezer requirement.

Airlocks

Fluid lines will be installed in the airlocks to supply chilled water to atmospheric heat exchangers. The chilled water will be supplied to the airlocks by the attached payload loop. The pump, controls, and heat exchangers for the attached payload loop are located in the core modules. Temperature sensors will be installed at the inlet and the outlet of the atmospheric control heat exchanger in the airlock.

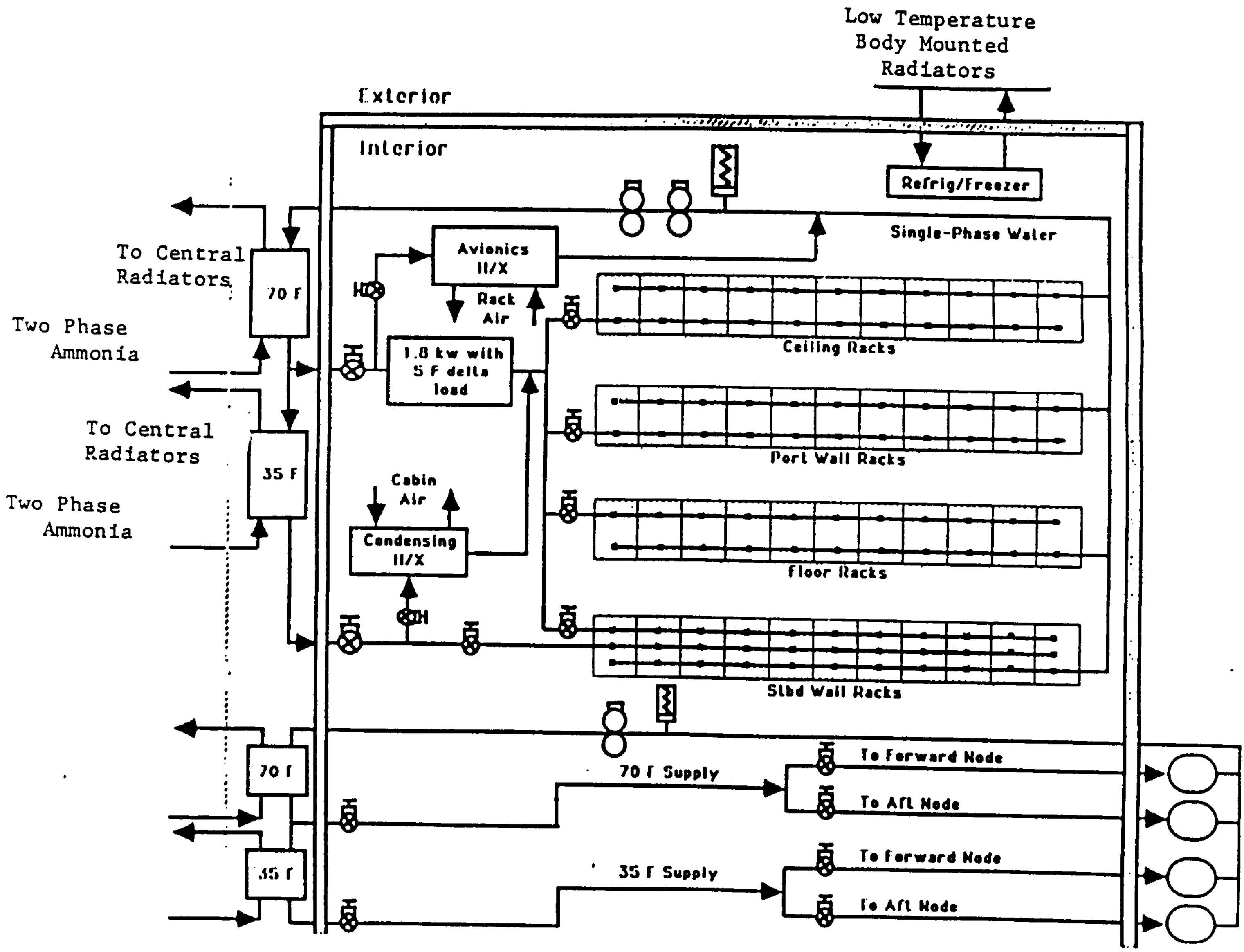

Figure 10.3-1 USL Thermal Control System

10.4 THERMAL CONTROL SYSTEM REFERENCES

1) Space Station Definition and Preliminary Design, WP-01, Book 3, U.S. Lab Module, SSP-MMC-00031, Rev. B, NAS8-36525. Martin Marietta Denver Aerospace, Denver, CO., October 31, 1986.

2) Space Station Definition and Preliminary Design, WP-01, Book 2, Common Module. SSP-MMC-00031, Rev. B, NAS8-36525. Martin Marietta Denver Aerospace, Denver, CO., October 31, 1986.

3) Space Station Definition and Preliminary Design, WP-01, Book 10, Airlocks. SSP-MMC-00031, Rev. B, NAS8-36525. Martin Marietta Denver Aerospace, Denver, CO., October 31, 1986.

4) Space Station Program Definition and Requirements, Section 3 System Requirements, SS-SRD-0001. Space Station Projects Office, Marshall Space Flight Center, Huntsville, AL, January 12, 1987.

11.0 ATTACHED PAYLOADS

11.1 ATTACHED PAYLOADS OVERALL REQUIREMENTS

Overall requirements for the attached payloads are presented in Table 11.1-1.

Table 11.1-1 Attached Payloads Overall Requirements

1) Payloads will be mounted on stationary or rotating attachment provisions on the Resource Nodes.

2) Tethered Deployment shall be considered as an alternative to attachment for payloads with sensitive environmental requirements.

3) Interface Monitoring and Protection. Space Station and platforms shall provide monitoring, measurement and protection of all interfaces that provide data, power, cooling, or similar resources to payloads such that a payload failure or payload misuse of resources cannot result in adverse impact on other payload or other operations.

4) Servicing - None

5) Contamination - None

6) Standard Interfaces - Interfaces shall be standarized appropriately so that any payload can be easily interchangeable between the manned element and attached payload.

The integration of fluids from attached payloads to other Space Station elements is presently an open issue. The baseline configuration for the attached payloads does not require fluids to be integrated. As of the October 1986 time frame, the attached payloads community preferred to be autonomous because of possible operational constraints imposed by interfacing with the station during operation.

The alternatives to interfacing with the station are to either vent waste gases to the external environment or store the waste quantities for return to earth. Venting constraints are becoming more restrictive with the new station configuration, and experiment operations may become very limited with the new contamination requirements. This would say that each attached payload would be required to include in its design a gas collection and storage system which would require additional plumbing, tanks, possibly compressors and most likely additional EVA time.

11.2 ATTACHED PAYLOADS FLUID SYSTEMS REQUIREMENTS

Attached payloads listed in Table 11.2-1 were identified in a NASA Lewis study as candidate systems that could benefit from fluid system integration.

Table 11.2-1 Annual Waste Gases from Attached Payloads (lbm/yr)

Mission/Fluids	1995	1996	1997	1998	1999	2000	2001	2002
SAAX 001 - Cosmic Ray Nuclei Experiment								
CO_2	243	485	243					
N_2	155	309	155					
SAAX 021 - Superconducting Magnet Facility								
He	193	772	772	772	772	772	772	772
SAAX 207 - Solar Terrestrial Observatory								
Ar	322	322	322	322	322	322	322	
N_2	230	230	230	230	230	230	230	
TDMX 2311 - Long Term Cryogenic Storage								
H_2			140	140	448	140		
TDMX 2421 - Active Optic Technology								
He				88	88			
Totals	1143	2118	1950	1552	1772	1464	1324	772

Derived from the Mission Requirements Database and the Critical Evaluation Task Force (CETF)

11.3 ATTACHED PAYLOADS FLUID SYSTEMS DESCRIPTIONS AND CONFIGURATIONS

The NASA study recommended providing common utility ports at available payload attach points for waste gas disposal in the integrated waste fluid system. A further assessment of experiment venting constraints and commitments of attached payloads scheduled for flight will need to be performed before the benefits of fluid system integration versus nonintegration can be assessed.

11.4 ATTACHED PAYLOADS REFERENCES

1) Peterson, T., Space Station Fluid Inventories of the Integrated Waste Fluid and Integrated Water Systems, PIR No. 159. NASA Lewis Research Center, Cleveland, OH, March 25, 1987.

2) Space Station Program Definition and Requirements, Section 3: System Requirements, SS-SRD-0001, Rev. A. Space Station Projects Office, Marshall Space Flight Center, Huntsville, AL, January 12, 1987.

12.0 FLUID SERVICER/VEHICLE ACCOMMODATIONS

The Space Station long range goals include the repair and servicing of various space based satellites and platforms. To accomplish this goal requires the use of transport vehicles such as the Orbital Maneuvering Vehicle (OMV), the Orbital Transfer Vehicle (OTV) or the Manned Maneuvering Unit (MMU) to transport satellites and platforms to and from the Space Station (SS) for repair or refueling. To refuel a spacecraft on-orbit will require the use of the mono-propellant version of Orbital Spacecraft consumables resupply system (OSCRS) for hydrazine users or the Superfluid Helium Tanker (SFHT) for resupply of Superfluid Helium (SFHe).

12.1 FLUID SERVICER/VEHICLE ACCOMMODATIONS OVERALL REQUIREMENTS

The top level requirements for fluid serviced vehicle accommodations are to provide for post IOC Space Station use of a National Space Transportation System (NSTS) shuttle based system which will be transported aboard the shuttle to and from Space Station and refueled and serviced on the ground. This will require protected storage with power, communications, data management and structural interfaces.

12.2 FLUID SERVICER/VEHICLE ACCOMMODATIONS FLUID SYSTEMS REQUIREMENTS

There are no fluid subsystem requirements for IOC SS with regard to fluid servicers or vehicles. The only fluid requirements at IOC are for scarring of the Integrated Nitrogen System for growth to support a low and high pressure port for a servicing facility and high pressure ports for the OMV, an Enhanced Maneuvering Unit (EMU) and an Extra vehicular Excursion Unit (EEV).

12.3 FLUID SERVICER/VEHICLE ACCOMMODATIONS FLUID SYSTEMS DESCRIPTIONS AND CONFIGURATIONS

12.3.1 Orbital Maneuvering Vehicle Description and Configuration

The OMV configuration and description are covered in detail in the Space Station Architecture Propellant System Databook, EP 1.1.

12.3.2 Orbital Transfer Vehicle (OTV) Description and Configuration

The OTV configuration and description are covered in detail in the Space Station Architecture Propellant System Databook, EP 1.1.

12.3.3 Manned Maneuvering Unit (MMU) Description and Configuration

The MMU configuration and description are covered in detail in the Space Station Architecture Propellant System Databook, EP 1.1.

12.3.4 Orbital Spacecraft Consumables Resupply System (OSCRS) Descriptions and Configurations

The OSCRS configuration and descriptions are covered in detail in the Space Station Architecture Propellant System Databook, EP 1.1

12.3.5 Superfluid Helium Tanker (SFHT) Description and Configuration

12.3.5.1 SFHT General Description

Initially resupply will be accomplished as a Shuttle based operation. A typical resupply operation would use the SFHT mounted to a pallet in the Shuttle Cargo Bay, once on orbit, the user satellite will be safed by Satellite RF Control, and appendages configured for retrieval with the orbiter Remote Manipulator System (RMS). The RMS will place the satellite on the SFHT berthing equipment, where it will be secured with latches. After the umbilicals are installed and verified to be functional, the Extra vehicular Activity (EVA) crew is no longer required for childown of Super Fluid Helium (SFHe) transfer. Fluid transfer is then controlled by a mission specialist from the Aft Flight Deck (AFD) Control Panels. Future growth would call for use of SFHT on an OMV. System requirements for the SFHT are shown in Table 12.3-1.

Table 12.3-1 Primary Superfluid Helium Tanker Requirements

1) Provide the versatility to satisfy NASA requirements for resupply of SFHe to a variety of users for initial design considerations SIRTF resupply shall be considered the design baseline.

2) Provide an adaptable and versatile SFHT design that can meet the requirements for orbital resupply of SFHe into the next century without major hardware modifications.

3) Meet hold times of four weeks on the ground and nine months on orbit.

4) Designed for low cost maintenance by using ground based check-out, maintenance, overhaul and adjustment.

5) Designed to be compatible with use on an OMV.

6) Operating Life; 50 Cycles

7) Useful Life; 20 Years

8) Shelf Life; 20 Years

9) Withstand surges from zero pressure to peak surge pressure and return to Maximum Expected Operating Pressure (MEOP) within 20 miliseconds.

10) Safety redundancy shall satisfy NHB 1700.7A (Two-fault tolerance to a hazard).

11) No credible single failure shall result in permanent inability of SFHT to complete mission. (One-fault tolerance to mission success)

12) Conform to Orbiter Payload bay envelope.

Table 12.3-1 Primary Superfluid Helium Tanker Requirements (Continued)

13) Conform to Space Station Satellite Servicing Facility envelope.

14) Center of Gravity compatible with the Orbiter, Space Station and OMV.

15) $\frac{\text{Maximum Total Loaded System Weight}}{\text{Helium Weight}} = 4$

16) Tankage capacity of 388.4 cu. ft. SFHe (141.2 cu. ft. for SIRTF + 176.6 cu. ft. for system cooldown + 70.6 cu. ft. for Misc. losses and margin reserves)

12.3.5.2 SFHT Performance Requirements - Table 12.3-2 lists the potential SFHT users and their fluid requirements. SIRTF is defined as the baseline for system design and sizing considerations for SFHT, although, the maximum required volume identified by a single user is 247.2 cu. ft. for LDR. The SIRTF requirement is to supply 141.2 cu. ft. of SFHe which requires 176.6 cu. ft. additional SFHe for cooldown purposes. These quantities, plus unavailable liquid and margin reserves, indicate a fluid system tank volume of 388.4 cu. ft. or more.

Table 12.3-2 Superfluid Helium User Database

User	Helium Volume Cu. Ft.	Helium Phase
-AXAF	7.1	SFHe
-IR Telescope in Space	15.9	TBS
-MMPS/CPPF	7.1	SFHe & LHe
-Gravity Probe B	53.0	SFHe
-SIRTF	141.2	SFHe
-Lambda Point Experiment	7.1	SFHe
-Astromag	211.9	TBD
-Far IR/Subm Space Telescope	211.9	SFHe
-LDR	247.2	SFHe
-Submm Telescope	8.8	TBS
-Superconducting Magnet Facility	17.7	SFHe or LHe
-Planetary IR Telescope	17.7	SFHe

12.3.5.3 SFHT Configuration and Subsystems - The SFHT fluid system design provides for storage and transfer of superfluid helium. Since the thermal requirements to maintain helium in the superfluid condition are so unique, the SFHT is quite different from a conventional cryogenic tanker. The SFHT takes advantage of SFHe's unique properties to accomplish venting and fluid transfer. Because helium is a safe media for cargo bay purging, venting on board the orbiter while in a hold presents no hazard. The basic design uses two tanks which are separated by three layers of insulation blankets and vapor cooled shields. The shields are thermally coupled to the supports, lines, and wires to intercept most of the heat leaking into the insulated space.

The vacuum jacket is a leak before rupture pressure vessel so that the failure becomes controllable and the rate of heat transferred to the inner tank is reduced. This in turn reduces the rate of pressure buildup and also reduces the size of the emergency vent line. Both the inner tank and the vacuum jacket are designed to withstand at least 15 psia external pressure. This is necessary for the inner tank for protection against vacuum jacket failure, as well as to facilitate the rigorous leak checks that will be required, using a leak detection procedure that requires evacuation of the tank.

The fluid system schematic is shown in Figure 12.3-1 with the corresponding component listing shown in Table 12.3-3. To meet the two fault tolerance for safety and one fault tolerance for mission success, a total of 14 valves are required inside the vacuum jacket, and 16 external valves are used. The fill line is not thermally coupled to the vapor cooled shields in order to minimize heat leak during its use. This allows its heat to bypass the shield. The cold valves are located close to the inner tank wall to minimize piping heat leak, including the prevention of serious heat leak by thermal-acoustic oscillations that occur when open lines connect to the cold vapor space between a tank and a warm valve. Porous plugs are used to provide the phase separation for thermodynamic venting through the vapor shields.

12.3.5.5 SFHT Accommodations

The current IOC phase of Space Station calls for the use of the SFHT to provide a superfluid helium resupply capability, as a NSTS Shuttle based operation with a future growth option of Space Station storage for use with an OMV, leaving the current interfaces as structural and power only. Since resupply is to be done on the ground, there are no fluid interfaces defined at this time.

12.4 FLUID SERVICE/VEHICLE ACCOMMODATIONS REFERENCES

1) Space Station Architecture Propellant Systems Databook, EP 1.1, MCR-87-516, NAS8-36438. April 2, 1987, Martin Marietta Denver Aerospace.

2) Study and Design of a Superfluid Helium Tanker, Technical Proposal, Volume One, P87-61055-1. Mission Suitability, May 1987.

3) Space Station Definition and Preliminary Design, WP-01, Book 7 Vehicle Accommodations, SSP-MMC-00031 (Rev. A) NAS8-36525. Martin Marietta Denver Aerospace, June 1986.

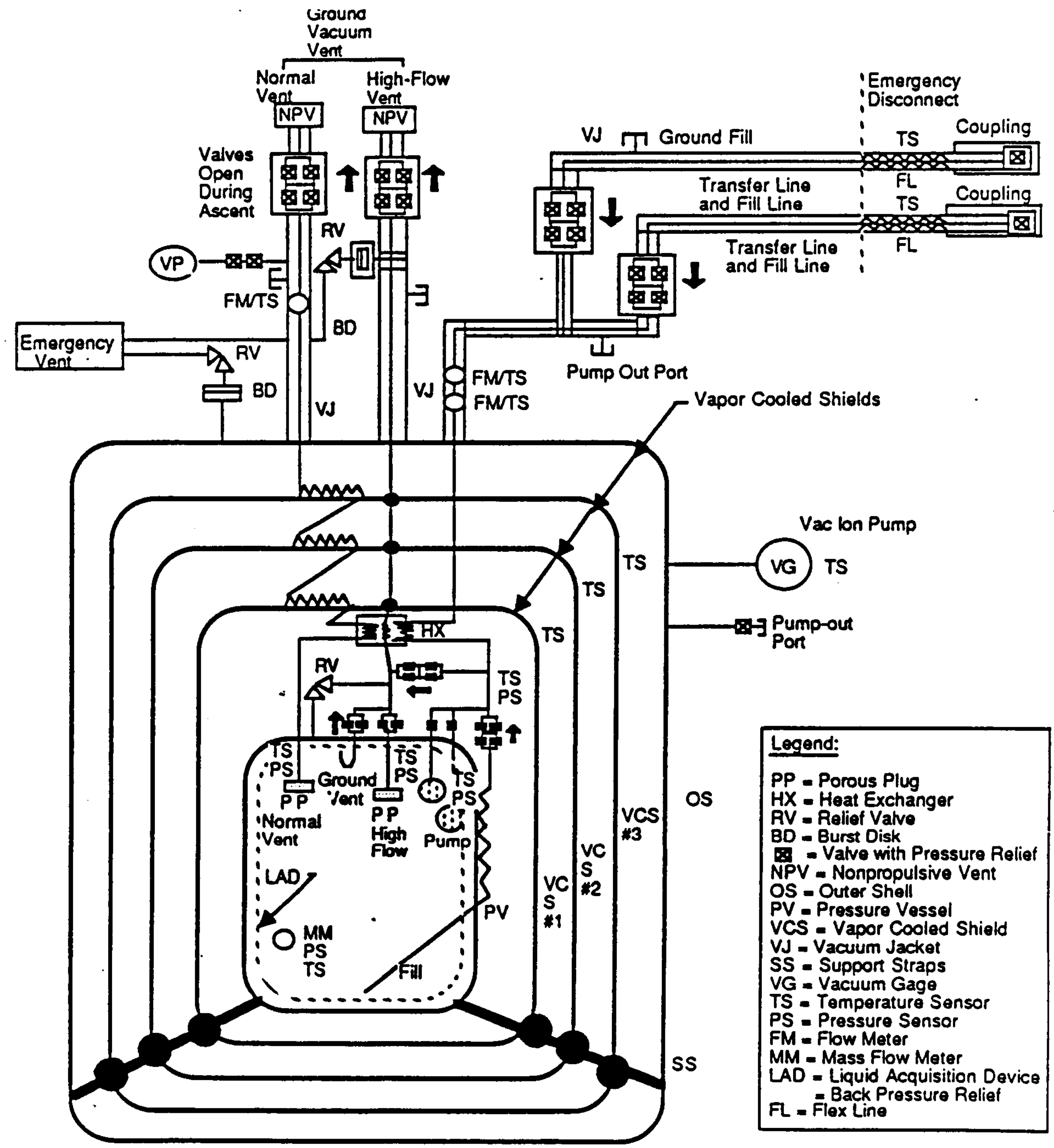

Figure 12.3-1 Superfluid Helium Tanker Fluid System Schematic

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Table 12.3-4 Superfluid Helium Tanker Component List

ITEM	PROGRAM APPLICATON	COMPONENT TYPE	QUAN REQD	SIZE (in)	PRESSURE MEOP (psia)	USAGE MEDIA	APPROX MASS (lb)	VENDOR NAME	VENDOR PART NUMBER
149	SFHT,	DISCONNECT,	2	1.0	VACUUM	SFHE	2.0	TBD	TBD
150	SFHT,	DISCONNECT, EMERGENCY	2	1.0	VACUUM	SFHE	3.0	TBD	TBD
160	SFHT,	MISC, BURST DISK	2	1.0	VACUUM	SFHE	0.9	TBD	TBD
151	SFHT,	MISC, FLEX HOSE	2	1.0	VACUUM	SFHE	8.0	TBD	TBD
169	SFHT,	MISC, HEAT EXCHANGER	1	MULTIPLE	VACUUM	SFHE	3.0	TBD	TBD
167	SFHT,	MISC, POROUS PLUG	1	.375	VACUUM	SFHE	0.3	TBD	TBD
168	SFHT,	MISC, POROUS PLUG	1	1.0	VACUUM	SFHE	1.2	TBD	TBD
164	SFHT,	MISC, PUMP, FEP	2	1.0	VACUUM	SFHE	0.8	TBD	TBD
165	SFHT,	MISC, PUMP, VACUUM	1	.375	VACUUM	SFHE	8.0	TBD	TBD
166	SFHT,	MISC, PUMP, VACUUM GAGE ION	1	.5	VACUUM	SFHE	3.0	TBD	TBD
161	SFHT,	MISC, VENT ASSY, NON-PROPULSIVE	1	1.0	VACUUM	SFHE	0.3	TBD	TBD
162	SFHT,	MISC, VENT ASSY, NON-PROPULSIVE	1	.375	VACUUM	SFHE	0.3	TBD	TBD
163	SFHT,	MISC, VENT ASSY, NON-PROPULSIVE	1	MULTIPLE	VACUUM	SFHE	0.5	TBD	TBD
147	SFHT,	PRESSURE VESSEL, ISOGRID	1	MULTIPLE	VACUUM	SFHE	750.0	TBD	TBD
148	SFHT,	PRESSURE VESSEL, STIFFENED MONOCOQUE	1	MULTIPLE	VACUUM	SFHE	1500.0	TBD	TBD
174	SFHT,	SENSOR, FLOW METER, GAS	1	.375	VACUUM	SFHE	1.0	TBD	TBD
173	SFHT,	SENSOR, FLOW METER, LIQUID	2	1.0	VACUUM	SFHE	1.0	TBD	TBD
172	SFHT,	SENSOR, MASS METER	1	TBD	VACUUM	SFHE	0.1	TBD	TBD
170	SFHT,	SENSOR, PRESSURE	5	TBD	VACUUM	SFHE	0.8	TBD	TBD
171	SFHT,	SENSOR, TEMPERATURE	15	TBD	VACUUM	SFHE	0.2	TBD	TBD
155	SFHT,	VALVE, MANUAL, SHUT-OFF	1	1.0	VACUUM	SFHE	1.0	TBD	TBD
158	SFHT,	VALVE, RELIEF	2	1.0	VACUUM	SFHE	3.0	TBD	TBD
159	SFHT,	VALVE, RELIEF	1	1.0	VACUUM	SFHE	2.0	TBD	TBD
156	SFHT,	VALVE, SEAL-OFF, VACUUM	1	1.0	VACUUM	SFHE	1.0	TBD	TBD
157	SFHT,	VALVE, SEAL-OFF, VACUUM	4	0.5	VACUUM	SFHE	0.5	TBD	TBD
154	SFHT,	VALVE, SOLENOID, LATCHING	4	1.0	VACUUM	SFHE	3.0	TBD	TBD
152	SFHT,	VALVE, SOLENOID, LATCHING W/BPR	6	.375	VACUUM	SFHE	1.5	TBD	TBD
153	SFHT,	VALVE, SOLENOID, LATCHING W/BPR	22	1.0	VACUUM	SFHE	4.0	TBD	TBD